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Vol. II JANUARY, 1915 No. 1

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, JANUARY 27, 1915,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Business of the Meeting: To choose a committee of five to nominate officers for the ensuing year.

Mr. Nathan H. Daniels, member of the American Institute of Electrical Engineers, will read a paper entitled "Insurance as an Aid to Engineers."

S. E. TINKHAM, *Secretary.*

PAPERS IN THIS NUMBER.

"The Commission-Manager Form of Government and Its Relation to the Engineering Profession." Henry M. Waite.

(Presented November 18, 1914.)

Discussion of "The Mechanics of Reinforced Concrete," with Author's Closure.

CURRENT DISCUSSIONS.

Paper.	Author.	Published.	Discussion Closes.
"Phosphate Rock Industry."	L. W. Tucker.	Dec.	Feb. 10.
"Power Plant at Wachusett Dam."	Thayer and Allardice.	Dec.	Feb. 10.

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FEBRUARY MEETING OF THE SANITARY SECTION.

A SPECIAL meeting of the Sanitary Section will be held Wednesday evening, February 3, 1915, in the library of the Society, Tremont Temple, at 7.45 o'clock.

The subject of the meeting will be "Garbage Disposal."

Dr. Frederic Bonnet, Jr., Professor of Chemistry at the Worcester Polytechnic Institute, will present a paper on "Garbage Disposal at Worcester, Mass.," illustrating it with lantern slides.

Mr. W. J. Springborn, manager of the New Bedford Extractor Company, will speak on the new plant for garbage treatment now in operation at New Bedford, Mass.

Others have been invited to participate in the discussion.

FRANK A. MARSTON, *Clerk*.

MINUTES OF MEETINGS.

BOSTON, December 16, 1914. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Mr. Harrison P. Eddy, who introduced as the presiding officer Vice-President Charles R. Gow. There were present 92 members and visitors.

By vote the reading of the record of the last meeting was dispensed with, and it was approved as printed in the December JOURNAL.

The Secretary reported for the Board of Government that it had elected the following to membership, in the grades named:

Members: John Patrick Cronin, Allan Curtis, Eric Lars Johnson, Walton Harvey Sears and Burdett Cardale Thayer.

Juniors: William Rea Holway, Carl Louis Stucklen and Carl Wilbur Wood.

The Vice-President announced the death of Lucian A. Taylor, a member of the Society, which occurred November 19, 1914, and by vote the President was requested to appoint a committee to prepare a memoir. The committee appointed consists of Messrs. Wm. E. McClintock and Frank E. Hall.

Vice-President Gow stated that the subject of the evening was "The Hydro-Electric Power Plant at the Wachusett Dam, Clinton, Mass.," and introduced the authors, Mr. Elliott R. B. Allardice and Mr. Burdett C. Thayer. The paper was read by Mr. Allardice, and Mr. Thayer explained the stereopticon views thrown on the screen. The lantern used was one which had recently been presented to the Society by Mr. John R. Freeman, one of the past presidents.

At the conclusion of the reading of the paper, a most interesting discussion took place, in which the following gentlemen took part: Frederic P. Stearns, Dexter Brackett, Harold K. Barrows, Charles M. Allen, Ira W. McConnell, William L. Puffer, Alfred O. Doane and Frank B. Sanborn.

Adjourned.

S. E. Tinkham, *Secretary.*

SANITARY SECTION.

Boston, Mass., November 27, 1914. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the library of the Society, Tremont Temple.

The meeting was called to order at 7.50 o'clock by Chairman Bertram Brewer, who introduced the speaker of the evening, Mr. Langdon Pearse, Division Engineer of the Sanitary District of Chicago.

Mr. Pearse gave a very interesting talk on "The Industrial Wastes of Chicago, with Particular Reference to the Packing Industry." Lantern slides were used to illustrate his remarks.

The meeting passed a vote of thanks to Mr. Pearse for his courtesy in addressing the Section during his brief stay in Boston.

There were 55 present at the meeting.

The new projection lantern presented to the Society by Mr. John R. Freeman was used for the first time in a meeting of the Society.

FRANK A. MARSTON, *Clerk.*

BOSTON, MASS., December 9, 1914. — The December meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the library of the Society, Tremont Temple. The meeting was opened at 8 o'clock P.M. by Chairman Bertram Brewer.

The records of the May meeting and of the June excursion were approved as printed in the JOURNAL. The record of the November special meeting was read and approved.

The report of the special committee on "Toilet Regulations for Industrial Establishments" was presented by Robert Spurr Weston, chairman. After giving a brief discussion of the work done by the committee, Mr. Weston read a letter from Mr. T. Howard Barnes suggesting certain modifications in the proposed "Regulations." Mr. George A. Carpenter, a member of the special committee, read a letter from a prominent manufacturer expressing approval of the committee's report.

The Regulations were discussed and a number of changes made. The adopted regulations will be published in the February issue of the JOURNAL.

A copy as adopted has been forwarded as directed, and receipt thereof acknowledged by the Commissioner of Labor and Industries.

Following the business meeting, Mr. Harrison P. Eddy, president of the Society, presented a paper on "The Economic Depth of Trickling Filters." A paper was also presented by Mr. H. W. Clark, chief chemist to the Massachusetts State Department of Health, on "A Study of Depth of Filter Material in Connection with Trickling Filter Efficiency."

There were 48 present at the meeting.

Meeting adjourned at 10.20 o'clock.

FRANK A. MARSTON, *Clerk.*

BOSTON, MASS., January 6, 1915. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society library, Tremont Temple.

The meeting was opened at 8 o'clock by the Chairman.

Pursuant to instructions from the Executive Committee, the Chairman announced the appointment of a special committee to study and report on "Methods of Design and Construction and Results of Operation of Submerged Pipe Lines for Outfall Sewers," as follows: Hiram A. Miller, chairman; DeWitt C. Webb, George A. Sampson, Edgar S. Dorr.

The Chairman then introduced Dr. J. W. M. Bunker, of the Sanitary Engineering Department, Harvard University, who gave an exceedingly interesting description of the forms and characteristics of "Diatoms." His talk, although of a popular nature, proved an admirable introduction to the collection of drawings, photographs and microscopic slides exhibited by Mr. F. F. Forbes, Superintendent of the Water Department of Brookline, Mass.

A vote of thanks was offered to Dr. Bunker and Mr. Forbes for their courtesy in presenting the subject of the evening in such an interesting manner.

There were 56 present. Meeting adjourned at 9.35 o'clock.

This meeting demonstrated in a new way the value and completeness of the stereopticon presented to the Society by Mr. Freeman, for without it the meeting would not have been possible. All of the objects were projected with clearness and in considerable detail.

FRANK A. MARSTON, *Clerk.*

MR. C. A. P. TURNER, whose paper on "The Mechanics of Reinforced Concrete" appeared in the issue of the JOURNAL for September, 1914, has presented to the Society a copy of a treatise entitled "Concrete-Steel Construction." This book, which was written jointly by Mr. Turner and Dr. Henry T. Eddy, was sent for the convenient reference of those who wish to study the subject more at length after reading the discussion of his paper.

APPLICATIONS FOR MEMBERSHIP.

[January 11, 1915.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Appleton, Arthur Benson, Beverly, Mass. (Age 28, b. Beverly, Mass.) Educated in Beverly public schools and Mass. Inst. of Tech., where he was a student for three years. From 1907 to 1909, survey and office work with Mr. Wm. S. Johnson, civil engineer, Boston; from 1910 to 1912, with E. L. Ransome on construction work, and with State Board of Health on survey work, Neponset River; from 1912 to 1914, with Mass. Highway Comm. on estimating, designing and checking of reinforced concrete bridges, also computing and drafting; from 1914 to date, with city engineer, Lynn, Mass., in charge of party. Refers to C. B. Breed, H. P. Burden, J. L. Howard, W. S. Johnson, R. H. Sutherland and W. L. Vennard.

Buckley, Wm. Joseph, Lynn, Mass. (Age 35, b. Lynn, Mass.) Graduate Mass. Inst. of Tech., 1912, civil engineering course. From July to Oct., 1909, rodman, U. S. Engineer's Office, Boston; from March to June, 1910, rodman with B. & M. R. R.; from June to Oct., 1910, rodman with N. Y. C. & H. R. R. R., construction dept.; from July to Oct., 1911, recorder, U. S. Engineer's Office, sounding and boring of Boston Harbor; from Oct., 1912, to April, 1913, timekeeper, Lucius Engrg. Co., Pittsburg, Pa., on bridge erection; from April to June, 1913, rodman with Boston Transit Comm., on East Boston Tunnel Extension; from June, 1913, to Nov., 1914, foreman, paymaster and timekeeper, Lucius Engrg. Co., on bridge construction. Refers to C. F. Allen, C. B. Breed, L. E. Moore and C. M. Spofford.

Corey, Kenneth Tolman, Pittsfield, Mass. (Age 26, b. Springfield, Mass.) From Sept., 1907, to June, 1909, general assistant with Geo. N. Merrill & Co., Springfield, Mass.; from June, 1909, instrumentman with Meikleham & Dinsmore of New York; from March, 1910, to date, engineer in charge and resident engineer with Durkee, White & Towne, Springfield. Refers to R. H. Barnes, F. P. Cobb, F. B. Locke, A. E. Tarbell.

Cowles, Martin Warren, Fairfield, Conn. (Age 21, b. New Haven, Conn.) Senior at Mass. Inst. of Tech., sanitary engineering course; two months at Surveying Camp, Maine. Refers to C. F. Allen, C. B. Breed, A. E. Burton, Dwight Porter, A. G. Robbins and C. M. Spofford.

Dowst, Everett Frank, Concord, N. H. (Age 26, b. Allentown, N. H.) Graduate of Norwich Univ., Northfield, Vt., 1912, civil engineering course. From July to Dec., 1912, draftsman with Southern New England R. R. Corp'n, Nashua, N. H.: Jan., 1913, chainman, Boston, Revere Beach & Lynn R. R.; from Feb. to Aug., 1913, chainman, B. & M. R. R.; from Sept., 1913, to Jan., 1914, transitman, N. H. State Highway Dept.; from April, 1914, to date, in private practice connected with Storrs Engineering Co., Concord, N. H. Refers to W. B. Howe, F. W. Lang, E. D. Storrs and J. W. Storrs.

Eisnor, John James, Boston, Mass. (Age 28, b. Lunenburg, N. S.) Graduate of Dalhousie Univ.; received diploma from H. Park College, Des Moines, Ia., 1913. Before graduation from Dalhousie, was for two years with N. Trans. R. R.; was for about four years with F. C. Wales, C.E.; 1911, transitman on assessors' survey, town of Marion; also in charge of building pier for Chas. S. Hamblin, Mattapoisett, and laid out and inspected work on William Strong's summer home at Woods Hole; 1912, transitman and inspector on $12 000 improvement of Henry Fay estate, Cape Cod; 1913, resident engineer and inspector on reinforced concrete bridge at Osterville, Mass.; transitman and inspector on Woods Hole drawbridge and sea wall, and superintendent for Taylor & Crosby Constr. Co. on concrete bridge; is at present with New England Gas and Coke Co. Refers to W. H. Cheney, W. E. McKay, D. S. Reynolds and J. C. S. Taber.

Hall, Charles Loring, Dorchester, Mass. (Age 21, b. Dorchester, Mass.) Student at Mass. Inst. of Tech., Class of 1915, civil engineering course. Refers to C. F. Allen, C. B. Breed, G. L. Hosmer, J. W. Howard and C. M. Spofford.

Harris, Gilbert Munday, Newton, Mass. (Age 26, b. Boston, Mass.) Received technical education chiefly at Boston Y. M. C. A. evening school and Franklin Union; student for one-half year at Tufts College, engineering course. From April, 1910, to Sept., 1911, rodman with B. & M. R. R.; from Sept. to Nov., 1911, with Mt. Washington Electric R. R. preliminary and location surveys; from Dec., 1911, to April, 1912, with Edison Co., St. Engrg. Dept.; from April to May, 1913, with B. & M. R. R., Real Estate Engrg. Dept., as transitman; from July to Oct., 1913, with the National Highway Association at South Yarmouth, Mass.; from Dec., 1913, to Feb., 1914, with Boston Finance Comm.; from March, 1914, to date, title researchman in Valuation Engineering Dept. of B. & M. R. R. Refers to C. H. Davis, G. W. Cutting, Jr., T. P. Perkins, C. H. Restall and F. B. Rowell.

Hubbard, Carl Perry, Woburn, Mass. (Age 27, b. Somerville, Mass.) Graduate of Tufts College, 1909, civil engineering course. From July, 1909, to Jan., 1910, inspector on reinforced concrete for Adolf Such, Hyde Park, Mass.; from Jan., 1910, to Sept., 1911, foreman, time-keeper and job superintendent with Aberthaw Const. Co., Boston; from Sept., 1911, to May, 1912, estimator and engineer with L. D. Willcutt Sons Co., Boston; from May, 1912, to July, 1914, resident engineer on reinforced concrete work with Lockwood, Greene & Co., Boston; from July, 1914, to date, superintendent of construction camp, state of Wisconsin. Refers to L. H. Allen, J. A. Garrod, F. W. Reynolds, E. H. Rockwell, F. B. Sanborn and L. C. Wason.

King, Arthur Caswell, Springfield, Mass. (Age 30, b. Taunton, Mass.) Graduate of Brown Univ., 1906, degree of B.S. in civil engineering. During summers of 1900 and 1901, rodman on preliminary surveys and inspector of sewer construction, also instrumentman on private land surveying, Taunton; during summer of 1905 and from 1906 to 1907, assistant, engineering dept., Mass. State Board of Health; from Feb., 1907, to date, with Springfield, Mass., Water Dept., as draftsman, instrumentman, estimator, inspector, assistant engr. in charge of party on land surveys and finally, since April, 1911, as superintendent's assistant; is also in charge of office at service building. Refers to H. K. Barrows, C. R. Gow, G. A. Carpenter, G. A. King, W. S. Johnson and E. E. Lochridge.

Nichols, John Robert, Cambridge, Mass. (Age 31, b. Somerville, Mass.) Graduate of Harvard College, 1906, degree of A.B.; course included engineering work chiefly. From Aug., 1906, to Feb., 1907, draftsman and reinforced concrete designer with contractor in Montreal; from Feb., 1907, to Dec., 1908, draftsman and reinforced concrete designer with Eastern Concrete Const. Co., Boston; from Feb. to July, 1909, with H. P. Converse & Co., on reinforced concrete design and estimate; from Sept., 1909, to June, 1913, instructor in civil engineering, Harvard Univ.; occasional consulting work; since June, 1913, engineer with Monks & Johnson, Boston, on design, detail and estimate of structures, mostly buildings, in reinforced concrete, wood and steel; Assoc. M. Am. Soc. C. E. Refers to Granville Johnson, L. J. Johnson, Mark Linenthal, C. E. Nichols, J. B. Newton and E. F. Rockwood.

O'Neil, Thomas P., Cambridge, Mass. (Age 39, b. Cambridge, Mass.) Educated in Cambridge public schools. From 1893 to 1900, brick mason; from 1900 to 1903, foreman mason; from 1903 to 1912, general contractor; from 1912 to date, supt. of sewers, Cambridge. Refers to W. A. Ford, Hugh Nawn, C. V. Reynolds and J. M. Wiseman.

Smith, Frederick Dexter, Malden, Mass. (Age 51, b. Foster, R. I.) Graduate of Mass. Inst. of Tech., civil engineering course, class of 1893. Since June, 1893, has been employed by Metropolitan Sewerage Comm., as assistant engineer, division engineer, and finally engineer in charge of Metropolitan Sewerage Works. Refers to Dexter Brackett, H. A. Carson, F. H. Fay, C. R. Gow, C. M. Spofford and J. R. Worcester.

SUMNER, MERTON ROGERS, Hopedale, Mass. (Age 28, b. South Paris, Me.) Graduate of Univ. of Maine, degree of B.S. in civil engineering. From June to Sept., 1911, with Stone & Webster, as student; from Sept., 1911, to Jan., 1912, instrumentman and assistant to resident engineer on electric inter-urban railway construction in Texas; from Jan., 1912, to July, 1912, inspector on contract timber work; from July to Nov., 1912, foreman of bonding work, using welded bonds of the E. Ry. I. Co., Cleveland, Ohio; from Nov., 1912, to Feb., 1913, transitman on hydro-electric power development, Big Creek, California; from Feb. to Mar., 1913, transitman on construction of Dam No. 3, Big Creek development; from March to May, 1913, chief inspector on construction of reinforced concrete intake and gate tower; rom May to June, 1913, chief power-house inspector on construction of power house No. 2; from June, 1913, to date, assistant engineer with Draper Co., Hopedale, Mass. Refers to W. A. Cobb, W. J. Dotten, F. A. Marston, J. P. Wentworth and H. A. Boardman.

SWATY, DAVID Y., Newtonville, Mass. (Age 37, b. Algoma, Wis.) Graduate of Univ. of Wisconsin, 1898, civil engineering course. From 1898 to 1899 with Philadelphia firm, as inspector of structural steel at mills and bridge shops; from Aug., 1899, to Jan., 1903, inspector of structural steel, draftsman, transitman, etc., with chief engr., Pennsylvania Lines West of Pittsburg; from Jan., 1903, to Sept., 1905, assistant engineer, M. of W., Southwest System Pennsylvania Lines West of Pittsburg; from Sept., 1905, to Nov., 1911, assistant engineer, M. of W., Northwest System Pennsylvania Lines West of Pittsburg; from Nov., 1911, to date, contracting engineer with Great Lakes Dredge & Dock Co. Refers to A. E. Hatch, L. E. Moore and L. G. Morphy.

LIST OF MEMBERS.

ADDITIONS.

HOLWAY, WILLIAM R.....................28 Bickerstaff St., Boston, Mass.
JOHNSON, ERIC L........................60 Clifton St., Dorchester, Mass.
WALDSTEIN, JULIUS....................317 Tremont Bldg., Boston, Mass.

CHANGES OF ADDRESS.

BESSEY, ROY F....................3109 Clarendon Road, Brooklyn, N. Y.
BRUNEL, RICHARD.........................39 Cedar St., Portland, Me.
ENEBUSKE, CARL C..................Augustana College, Rock Island, Ill.
FERGUSON, JOHN N. ....Ponkapoag, Mass.
MORRILL, F. P.............................28 Eliot St., Watertown, Mass.
NEGUS, ARTHUR I.........................117 Myrtle St., Melrose, Mass.
PETTEE, EUGENE E....................493 Commercial St., Portland, Me.

Powers, Charles F. . . . . .27 Hollingsworth St., Mattapan, Mass.
Preble, J. Jarvis. . . . . .45 Rich St., Waltham, Mass.
Rice, Arthur P. . . . . .34 Chestnut St., Everett, Mass.
Robinson, Ashley Q. . . . . .Room 9, Horton Block, Attleboro, Mass.
Saville, Charles. . . . . .3803 Gaston Ave., Dallas, Tex.
Sears, Calvin C. . . . . .Box 13, East Dennis, Mass.
Simpson, E. Roland. .176 Federal St., Boston, Mass.
Sokoll, Jacob M. . . . . .878 Dixwell Ave., New Haven, Conn.
Waring, Charles T. . . . . .Buzzards Bay, Mass.
Wentworth, John P. . . . . .7 Park Ave., Malden, Mass.
Wiseman, John M. . . . . .15 Beacon St., Boston, Mass.

DEATH.

Cochrane, Clifford N. . . . . .Died August 8, 1914

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and other desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

239. Age 43. Educated in Boston public schools and Mass. Agricultural College. Experience includes five years with distribution department of Metropolitan Water Board on pipe line surveys and construction, five years in city engineer's office, Waterbury, Conn., on drafting, computation surveys and construction, mill work and installation of septic tanks; and eight years with Board of Water Supply of New York City on Hudson River Crossing of Catskill Aqueduct; was assistant to division engineer on this work for six years and in direct charge for two years, when work was completed; has also had experience in engineering work for Bay State Street Railway Co., Underground Dept. Particularly desires position in Boston.

278. Age 20. High school graduate and student for one-half year at Boston Y. M. C. A. Co-operative Engineering School. Has had no practical experience. Is willing to start at small salary with opportunity to learn and advance.

279. Age 38. Has had nineteen years' experience as draftsman, designer, etc., on various kinds of industrial plants and their equipment, including reinforced concrete and steel mill construction; has had special training in dye-house work for woolen and worsted mills. Desires position as draftsman. Salary desired, $5 per day.

280. Age 25. Student for four years at universities of Valparaiso and Wisconsin. Experience includes five field seasons on topographic mapping with U. S. Geological Survey; six months as draftsman with Lynn Water Department, and two seasons as rodman and inspector with B. & M. R. R. Desires position as engineer or draftsman; would take temporary position. Salary desired, $80 per month.

281. Age 38. Educated in public schools of Boston and at Tufts College in scientific course. Experience includes two years on highway construction; two years in mining engineering; five years on river and harbor improvement and ten years as designer, estimator, etc., on sewerage work, including office experience as assistant engineer. Desires position as inspector or as assistant in field or office. Salary desired, $150 per month.

282. Age 37. Student for five years in evening engineering classes of Boston Y. M. C. A. Has had fifteen years' engineering experience, including designing of special tools and machinery and improving of factory equipment and systems for General Electric Co., detailing and layout of industrial and power plants and designing of structural steel for various architects and engineering firms. Desires immediate engagement at reasonable salary.

283. Age 31. Student for two years at Norwich Univ., Vermont, civil engineering course. Has had about five years' experience as designer and draftsman, also two years' practical experience in foundry; is familiar with all kinds of mathematical computations, including higher mathematics; good detailer and designer on steel and reinforced concrete. Desires a permanent position as steel designer. Salary desired, $25 per week.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Annual Report of Interstate Commerce Commission for 1914.

Annual Report of Secretary of Commerce for 1914.

Annual Report of Superintendent U. S. Coast and Geodetic Survey for 1914.

Production of Asphalt, Related Bitumens, and Bituminous Rock in 1913. David T. Day.

Basket Willow Culture. George N. Lamb.

Chinese and Japanese in United States in 1910.

Statistics of Clay-Working Industries in United States in 1913. Jefferson Middleton.

Hints on Coal-Mine Ventilation. J. J. Rutledge.

Production of Cobalt, Molybdenum, Nickel, Tin, Titanium, Tungsten, Radium, Uranium and Vanadium in 1913. Frank L. Hess.

Contributions to Economic Geology, 1912. Part II. — Mineral Fuels. Marius R. Campbell.

Contributions to Stratigraph of Southwestern Colorado. Whitman Cross and Esper S. Larsen.

Copper in 1913. B. S. Butler.

Supply and Distribution of Cotton, 1914.

Statistics of Express Companies in United States, 1912.

Fuel in Briquetting in 1913. Edward W. Parker.

Gems and Precious Stones in 1913. Douglas B. Sterrett.

Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1913. Charles G. Yale.

Gold, Silver, Copper, Lead and Zinc in Utah in 1913. V. C. Heikes.

Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1913. Charles W. Henderson.

Humidity of Mine Air. R. Y. Williams.

Production of Iron Ore, Pig Iron and Steel in 1913. Ernest F. Burchard.

Lead in 1913. C. E. Siebenthal.

Production of Metals and Metallic Ores in 1912 and 1913. J. P. Dunlop.

Mineral Resources of Alaska, 1913. Alfred H. Brooks and others.

Montana Group of Northwestern Montana. Eugene Stebinger.

Moorcroft Oil Field and Big Muddy Dome, Wyoming. V. H. Barnett.

Constitution of Natural Silicates. Frank Wigglesworth Clarke.

Norway Pine in Lake States. Theodore S. Woolsey, Jr., and Herman H. Chapman.

Study of Oxidation of Coal. Horace C. Porter and O. C. Ralston.

Ore Deposits in Sawtooth Quadrangle, Blaine and Custer Counties, Idaho. Joseph B. Umpleby.

Phosphate Deposits of South Carolina. G. Sherburne Rogers.

Precise Leveling from Brigham, Utah, to San Francisco, Cal. William Bowie.

Prevention of Accidents from Explosives in Metal Mining. Edwin Higgins.

Primary Triangulation on One Hundred and Fourth Meridian, and on Thirty-Ninth Parallel in Colorado, Utah and Nevada. William Bowie.

Production of Platinum and Allied Metals in 1913. David T. Day.

Quarry Accidents in United States in 1913. Albert H. Fay.

Reconnaissance in Canyon Range, West-Central Utah. G. F. Loughlin.

Results of Spirit Leveling in Hawaii, 1910 to 1913 inclusive. R. B. Marshall.

Slate in United States. T. Nelson Dale and others.

Taxation and Revenue Systems of State and Local Governments, 1912.

Water-Supply Papers 332-C, 340-C, D and E, 344, 363 and 364.

State Reports.

Massachusetts. Report of Directors of Port of Boston on Fish as a Food or Fish against Meat.

Massachusetts. The Port of Boston, U. S. A.

Pennsylvania. Reports of Water Supply Commission for 1910–12 inclusive. Gift of Desmond FitzGerald.

City and Town Reports.

Boston, Mass. Larger Aspects of Passenger Transportation in Metropolitan Boston.

Cambridge, Mass. Annual Report of City Engineer for 1913.

Concord, N. H. Report on Water Supply. G. C. Whipple.

Detroit, Mich. Annual Report of Department of Parks and Boulevards for 1913.

Detroit, Mich. Annual Report of Water Commissioners for 1913–14.

Northampton, Mass. Annual Reports of City Officers for 1913.

Miscellaneous.

American Society for Testing Materials. Proceedings for 1914. Gift of L. C. Wason.

Encyclopædia Britannica, Ninth Ed., Vols. I to XXV inclusive.

Canada, Dept. of Mines. Production of Coal and Coke in Canada in 1913, by John McLeish; Report on Building and Ornamental Stone of Canada, Vol. II, by William A. Parks; Gypsum in Canada, by L. H. Cole.

Cape Cod and Its Canal. J. W. Miller.

The Cape Cod Canal. August Belmont.

The Cape Cod Canal. A. St. Clair Smith.

Concrete-steel Construction. Part I. Buildings. Henry T. Eddy and C. A. P. Turner. Gift of latter.

Conditions and Outlook of the Big New Waterway across Cape Cod.

New International Encyclopædia, Vols. I to VI inclusive.

National Importance of Cape Cod Canal. Colby M. Chester.

American Sewerage Practice, Vol I. Leonard Metcalf and H. P. Eddy. Gift of the authors.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

United States Government. — NAVY DEPARTMENT. — *Navy Yard, Boston.* — Work on building a slip for ship construction has been commenced.

Commonwealth of Massachusetts. — METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — The new screen house at the East Boston Pumping Station is under construction; work under compressed air is being carried on at the siphon at Washington Street, West Roxbury, and the new 60-in. cast-iron relief outfall sewer at Nut Island is being laid.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

Charles River Reservation. — Plans are being prepared for construction of reinforced concrete and stone masonry arch bridge over the Charles River at North Beacon St., Boston and Watertown.

Middlesex Fells Parkway. — Reconstruction of burned portion of Wellington Bridge.

Winthrop Shore Reservation. — Constructing sea wall at northerly end of reservation.

City of Boston. — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets:

East First St.,	South Boston.	Sea wall.
Seaver St.,	Walnut Ave. to Humboldt Ave.	Grading.
Seaver St.	Humboldt Ave. to Blue Hill Ave.	Grading.
Spring St.,	Gardner St. to Webster St.	Bituminous macadam.

PUBLIC WORKS DEPARTMENT, SEWER AND WATER DIVISION, SEWER SERVICE. — The construction of the Davenport Brook conduit is in progress between Adams and Frederika Sts., Dorchester, where it is 11 ft. by 5 ft. 6 in., and between Carruth and Wessex Sts., where it is 7 ft. 4 in. by 7 ft. 6 in.

At the pipe siphon under the Metropolitan sewer on Washington St., West Roxbury, tunneling under air pressure.

In Beach St., between Atlantic Ave. and South St., 4 ft. by 5 ft. 6 in. concrete sewer is being laid to replace a 4 ft. by 5 ft. wooden sewer.

Work on the Union Park St. Sewage Pumping Station is in progress.

Aberthaw Construction Company. — Quincy, Mass. — For the Fore River Shipbuilding Corp., the Aberthaw Construction Company is building a storage building on which the steel frame is now completed. Brickwork is being started, and the concrete floors are being put in at the same time. The interesting features of this work are the handling of the masonry under cold weather conditions, the building being enclosed by canvas and heated.

The Fore River Shipbuilding Corp., Quincy, Mass., has the following work in progress:

U. S. Battleship *Nevada*.

Eight U. S. submarine boats.

Four torpedo boat destroyers for the U. S. Navy.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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THE COMMISSION-MANAGER FORM OF GOVERNMENT AND ITS RELATION TO THE ENGINEERING PROFESSION.

By Henry M. Waite, City Manager of Dayton, Ohio.

(Presented November 18, 1914.)

It gives me great pleasure to be able to try and explain in a brief way some of the points which have come up in the working out of our new charter in Dayton. For cities of Dayton's size, it has been somewhat of an experiment to the public in general and in fact to the minds of a great many people who have advocated this particular form of government. We have avoided going before the public and attempting in any way to advise as to how we have felt, believing that our real duty was to remain on the job and make it a success and then do our talking afterwards. We feel, however, that now, after having had it in operation for nearly eleven months, we can say very candidly that it has so far proved itself as a practicable means of governing cities of at least that size. In looking at it from the point of the engineer, it is somewhat difficult to draw any direct comparison of efficiency until we have completed our figures for the year, and I will therefore briefly go over some of the things, particularly our charter, with a little of the history leading up to

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Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before March 15, 1915, for publication in a subsequent member of the Journal.

that charter, and then some of the diversified work it is necessary to do in the running of a city.

We all realize, of course, in the first place, that the more efficient the government the more efficient the employee. Mr. Bryce, in "The American Commonwealth," says, "There is no denying that the government of cities is the one conspicuous failure of the United States." This statement should not be too discouraging because I believe that we have appreciated that fact and have been for years improving our municipal conditions. In 1876 a New York commission was appointed to devise a plan for the government of cities outside of New York, and they suggested the following as the causes of failure of the old forms of municipal government: First, incompetent and unfaithful boards and officers. Second, the introduction of state and national politics into municipal affairs. Third, the assumption by the legislature of the direct control of local affairs. It has been some time since we began to realize that the city was a business corporation rather than an integral part of the state. In 1882, Brooklyn took a step toward concentrated power in connection with concentrated responsibility, by giving the mayor absolute appointive power, without the confirmation of a council, of the principal executive heads of departments. Mr. Woodruff epigrammatically states, "For policy we must elect; for efficiency we must appoint." This has been the difficult step to achieve. It means the breaking down of the political hold upon our municipal affairs, the lessening of the grasp of the professional politician who works for a well-oiled ward and precinct organization first, and efficiency in the municipal organization second. As Mr. Bryce again so aptly states, there is a want of method for fixing public responsibility on the governing persons and bodies. We know from experience that the political appointee's first allegiance is to his political machine. This tradition has shackled general advance. Our advance in municipal affairs, in municipal reforms, has been made, up to the last few years, under the old cumbersome federal form. Personally, I consider that the commission form, and by that I mean the direct commission form, is only a development of the federal form, and not a change, as by it you select through the ballot specific men for specific functions of government. The results of this, of course, have been partly good and partly bad.

In many instances we have been prone to still further harass and embarrass our municipal officers with laws and red tape, all tending to increase the cost of administration. We can say of American cities what Dante said of his own city, " They are like the sick man who cannot find rest upon his bed, but seeks to ease his pain by turning from side to side." Our failures have been due, primarily, to the form of government, and not entirely to the individuals who administer it.

If you will draw an organization chart of the federal form of municipal government you cannot conscientiously point to the department which is responsible for its failure. I have been somewhat surprised to find the complexity of the municipal organization in Massachusetts. I was in Springfield last night and looked over the organization chart drawn to represent the present Springfield charter. It made the ordinary Chinese laundry check look like thirty cents. But take even an ordinary form of federal government in the middle west where we have but the one board. Just let your minds for a moment draw that chart, which would be first the electorate and then the one body known as the council. It would also extend to the mayor and through each department to the city attorney, the auditor and the treasurer, and then the various functions of the municipal government beneath; following through your chamber or your council, connect up to the mayor, connect up again to the city attorney and the auditor and the treasurer, and you get a complex organization that no man would have in his own business.

It has been our custom always to hold the mayor responsible, yet we have absolutely tied his hands so that he really has no power and no possibility for individuality. You, in your own organizations, would not tolerate it for a minute, and yet we, the electorate, have put this kind of an organization up to our representatives of government and expected them to operate economically and efficiently. What man familiar with business organization and without political ambition would assume the responsibility of running such a municipal organization? With such an organization and with no power to change it, who would assume the responsibility of running the Pennsylvania Railroad, especially if, in addition to this limitation, he would be given men who must be put into certain jobs and allowed only one party from which to draw those men? To my knowledge, there are instances where city engineers have been told what inspectors to put on a certain piece of work after the contract had been let, and you know the answer. Again Mr. Bryce says, "Many of the mistakes which have marked the progress of American cities have sprung from deceptive conception. The aim was to make a city government where no officer by himself should have power enough to do much harm. The natural result of this was to create a situation where the officer had no power to do much good." In years past, we have laughed at that condition, and it is true that we have tried in every way possible by additional laws to surround our public officials in such a manner that they could not do much harm. That is the confidence that we, as a rule, have had in our public officials.

Municipal efficiency depends upon the divorce of politics from municipal affairs. This has been accomplished in Dayton. The laws of the state of Ohio now allow cities to write their own charters — to enjoy home rule. Dayton accepted the commission-manager form. Five commissioners were elected last November, a year ago, on the short, non-partisan ballot. They were all business men excepting one, who was a laboring man and a typesetter. The commission appointed a city manager, and it is in the manager's power to appoint the five Directors, for the departments of Law, Finance, Welfare, Safety and Service. The Director of Law, who is the city attorney, was on the charter commission and had more to do with the drafting of the charter than any one else. He is familiar with it in every detail. The Director of Finance has been connected with various manufactories in Dayton as treasurer, accountant and purchasing agent, and was a public accountant when appointed. The Finance Department includes the Divisions of Auditor, Treasurer and Purchasing Agent. The Director of Welfare was a minister in charge of a large parish, had studied civic conditions in this country and abroad, and was much interested in welfare work. He was doing his greatest service to the community outside his church. He has charge of the Divisions of Health, Recreation, Parks, Playgrounds and Amusements, Charities, and all welfare work.

The Commission was unable to recommend anybody in Dayton for the positions of directors of Safety and Service and strongly advised going out of the city for men to fill these two positions. As a consequence, the Director of Service was appointed from out of the city. He is a graduate of the Massachusetts Institute of Technology, has been connected with municipal work in various cities, was on the New York Aqueduct, has been connected with municipal research work, and was my principal assistant in Cincinnati. He has charge of all engineering, the construction, repairing and cleaning of streets and sewers, water-works, collection of garbage and ashes, and the supervision of all public utilities. The duties of the Director of Safety are the charge of the divisions of Police, Fire and Weights and Measures. This position has never been filled, and the city manager is now acting Safety Director, with the prospect that he will be able in time to develop material in either of those divisions suitable for the position of Safety Director, and we are very glad to say that we have been able to do this and that such an appointment will be made the first of the year.

From the above it will be seen that we have been able to select men trained in the particular position which they were called upon to fill. Furthermore, I cannot tell you to-day the political faith or party of any of the commissioners or of any of the directors, or any other appointees.

The commissioners form the legislative body and the manager is directly responsible to them. They are, if you please, a board of directors, and direct the policy of the city government. They meet once a week, passing all ordinances, referring questions which come to them to the city manager for investigation, action or report. Together with the city manager, they form the board of Sinking Fund Trustees, with the Director of Finance as secretary. The directors of the various departments are held responsible for their various departments. They meet once a week with the city manager, when important questions in each department are taken up and discussed.

Draw a chart of this form of organization and compare it with that of the federal. In our organization chart you have the electorate going direct to the commission, the commission direct to the city manager, the city manager direct to the functions of the government. It is the same organization that you would have in any of your own businesses or in any corporation. In which of these charts is there the greatest possibility for efficiency? In our organization every one knows that the officer's or employee's retention depends upon his results.

By a scientific budget the expenses of every department under the various divisions and subdivisionns are absolutely fixed, and our expenditures are thus limited to actual income. As an example of what that would mean in the governing of a city, we had occasion to make an 8 per cent. cut in all departments this year; as you know, in all municipal work, you first have to estimate your income, and it is necessary of course to make your budget for expenses come inside of your income. There was a falling off in some of our taxes, and we found in the month of July that we would have a decrease in our revenue, below what we had estimated, of about $50 000. By the use of the scientific budget aided by our accounting system (and by this accounting system I can go into the accountant's office to-day and know exactly the balance in every account, and at the end of each month the head of each department receives a financial statement which shows his original allowance in the budget, his expenditures to date, and his unencumbered balance), we were enabled to call in the head of each department and cut down our expenditures $45 000 in two days. The new balances were immediately furnished to each department and their organizations were brought to that new basis. I have attempted that in other cities where they have a fairly good budget but where each department always says, " Cut it off the other fellow."

To give an idea of the various activities which come before a city manager or before the head of any city government, I will run over briefly some of the things which we have done. We have had up with the engineers of the railroads the question of grade elimination, the plans have been prepared and we went before the people with a referendum bond issue for the city's portion of the elimination of the grade crossings. This was a somewhat peculiar and a very interesting condition, because the people of Dayton absolutely demanded that one of the things which the new form of government must do was to eliminate grade crossings. We proceeded immediately to get the plans prepared and had our estimates of the city's portion of the expense, and at our last election put the question before the people. They voted it down. In other words, the people put the responsibility on the commission. The commission immediately returned the responsibility to the public, and the public refused to pass the bonds. Of course, the peculiar financial condition had everything to do with the failure to pass the bonds, but at the same time the commission got the burden off their shoulders.

Dayton has never had a building code. A board or a commission was appointed, and a code is now being drafted and will be ready the first of the year. Street-car service has been improved, delays have been reduced, some re-routing is under way to give better service.

The curse, of course, of most American cities is their lack of a comprehensive planning system. Each one in his own subdivision will plan as he sees fit to gain the most from his property. We have appointed a planning commission which is now preparing an estimate of what it is necessary to do to proceed on a plan to plat the city three miles outside of its present limits.

The principal idea is that the success of any form of government must ultimately depend upon the people. If the people do not become and stay interested in that particular form of government, it will not be a success; regardless of what the government is, it must in the end go back to the people. So, therefore, the great thing to accomplish is to keep the interest of the people as closely as possible to the government, the government all the time giving the public the benefit of everything it is doing. So various associations were formed to keep the people interested. The Civic Music League was one of them, the idea being to start community music through community centers. It took so rapidly, however, and the people were so interested in it, particularly the musicians, that they started a series of concerts for this year. The form of these concerts is somewhat unique and interesting. They are giving six concerts in Memorial Hall, which will seat 3 000 people. The first concert was the Paulist choristers, with the complete house sold out at three dollars and fifty cents for the season of six concerts. This is a little less than sixty cents a concert. When you realize that the Civic Music League is bringing here such artists as John McCormack and Alma Gluck, as well as several very fine symphony orchestras, you begin to know what this has meant to Dayton. A three dollar and a half ticket is good for any seat in the house. Two weeks before each event tickets are sent in for reservations. If any preference is expressed, it is fulfilled as nearly as possible. The Civic Music League has sufficient money to meet all expenses in connection with the concerts, with a balance of $1 500. Next year the season tickets will be reduced to three dollars.

A new traffic ordinance has been formed and put into effect. An engineering firm has been engaged to aid us in designing methods of disposing of our garbage and wastes; we are doing the same thing with our sewerage system and our water-works. That is, we engage the best experts that we can get in the country for advisers and are proceeding with our plans on a comprehensive scheme for the future.

We have inaugurated a plan whereby the prosecutor holds an informal court every afternoon, and settles a great many cases outside the police court. Women police have been employed. We have expedited our public work by putting in an arrangement whereby we can borrow money in advance of the assessments, which was never done before, allowing the contractor to be paid as he proceeds. Our water system is somewhat antiquated, being originally planned for a city of 33 000 people. We now have a population of 125 000. You know the result. A great many of the 125 000 cannot be furnished water. In one place there is a drop from 58 lbs. on one side of the river to 25 lbs. on the opposite side.

A great many of our sewers are inadequate. All of these propositions are being worked out now on a comprehensive scale, to take care of a population which we figure will be 200 000 in 1930. Some of the details of the water-works were somewhat interesting. We found that cards had never been made on the engines, and as soon as we carded them we increased the horsepower 30 per cent. There were other interesting things which we found. An inch and a half steam connection for the first to the second receiver on a triple was found open. Nobody knows how long it had been open. We found in some of the valves that there were unequal lifts, there were unequal springs, and we saved about 50 per cent. There were about 50 per cent. of the springs that obeyed the impulse to lift at the proper time. There were innumerable things of that kind which were found. Our water is obtained from wells and our force pumps are the suction pumps.

We have established a municipal garage.

We increased the budget of the health department about 60 per cent. over that of the previous year, and it is very interesting, while this is far from engineering, it gives an idea of the complexity of the questions that come up. For example, in the city of Dayton we found that there were three distinct nursing activities, two philanthropic and one municipal. They were covering the same territory in some parts of the city by three nurses, and some parts of the city were without any. All of the nurses, both philanthropic and city, were brought together in the Welfare Department and so handled from that department that there is no duplication of effort, with a decreased cost. There was philanthropic effort in playgrounds and gardens associations, and we found that both they and the city were paying for experts. We combined issues, made one large committee, the city appointed part, the Playgrounds and Gardens Association appointed part, and all these efforts were brought together. As a sidelight, we told the citizens that, if they would clean up some of the vacant lots (and you will appreciate that after the flood there were a great many lots covered with rubbish as people cleaned out their yards into the first vacant place they could find), the city would haul off the rubbish and plow the lots, and it was most surprising to find that there were four hundred lots cleaned, four hundred dirty spaces turned into gardens, four hundred families had fresh vegetables without any cost, and four hundred families had a new interest in life. One garden that I know of particularly was kept by three children, and in addition to supplying themselves and some of their neighbors, they sold seventeen dollars' worth of vegetables from one lot.

Workhouse labor has been employed upon the streets in cleaning and in repairing and also in our public parks.

We have established schools for police and firemen and the fire department has started inspections of buildings. These things are undoubtedly done here in the same way, but they have not always been done in that part of the country.

Our accounting system is exactly the same as you would have in any private business. I doubt if any of you are familiar with ordinary accounting systems in cities. They have been changed and added to a great deal. Every time there was a new function there was a new book opened. It is almost impossible from the books of any of the cities that I have seen to get information which you or anybody else in his own private business would demand, and that is one of the first things we established in Dayton, — a modern bookkeeping system. Particular expenses are kept on unit bases.

We have diagrams which show the deadly parallel, and everybody is ranked on that parallel. There are no political debts to pay. Every man realizes that he stands on his own bottom. With our systems and our diagrams and charts we are able to put the city very close to a business basis.

Our charter requires that the commission employ a public accountant who keeps a running check on our books. You will notice that that is entirely outside of the manager's authority.

I think that I have been able to demonstrate that it is possible to apply business methods to the running of a city and I believe that I have shown that the commission-manager form of government stands for efficiency, publicity and concentrated responsibility. If you don't believe it, I would ask you to assume the duties of a city manager. The city manager is the point where every person puts his finger. We have a complaint station where all complaints come in and are distributed to the proper departments, with a counter check and a follow-up system. I don't need the follow-up system. They follow me up. We try to keep our office door open all of the time, and as a result ninety per cent. of my time is spent there. This is unfortunate in a great many respects, but it is working itself out, I believe, admirably. I think when the public finds that they can reach you they soon begin to believe they don't need to.

You can appreciate from this form of government that it is absolutely up to the city manager to make good or get out. The charter itself provides for a recall of the city manager. I do not know why that was put in; I don't think it was necessary, as the commissioners are subject to recall, and I hardly think that it is necessary to subject an appointive official to the recall. However, it is in the charter.

As I stated before, the city manager is not hampered by party or pull. It is customary, where I have been, under the old forms, when a new administration comes in, to clean the slate absolutely. I don't know whether that is true here or not, but generally, if the Republican party is in power and the Democrats come in, everybody moves out the first of the year. That is a principle. Imagine running your own business on that basis, — that is, every two years change the entire organization! How long would it be possible to operate a business under such management? When we took hold the first of the year, we told everybody in office he could continue in office, that his retention depended entirely upon his ability and efficiency, with the result that we have found a great many good men, admirable men, who are familiar with the work and are anxious to get ahead. Some of them fell by the wayside, naturally. They have been replaced, with the result that we are building up an efficient organization. As an example, one of the department heads in the treasurer's department was behind in some of his work. I knew nothing of it, it hadn't come to me, but some of the boys in the other departments heard of it. They doubled up from the other departments in that office at night and brought him up to date. I never heard of that before in any other form of government. My experience has been that they usually quit with their pencils in the air about 4 or 5 P.M. I am firmly of the belief that this particular form of government is the most efficient that has yet been tried, and I think I can repeat my opening statement, that the more efficient the government the the more efficient the employee.

I believe that the position of city manager is an opening with immense possibilities for the engineer. There are now twenty-one cities governed by city managers. It is a natural position for the engineer. The larger problems of American cities of to-day are purely engineering. In smaller cities, the city manager acts in the capacity of city engineer, and in fact acts as the head of all the functions. There is, however, to my mind, gentlemen, a great drawback in getting trained engineers interested in municipal work. They shrink from publicity. And I will say very candidly that if you do, it is a good game to stay out of. You have got to make up your mind, if you do go into this line of work, that you can't carry your feelings on your sleeve. It is a good deal as a man who had been mayor of Cincinnati when I first went there said to me,—"Waite, if you have a sense of humor you will last; if you haven't, they will drive you out of City Hall in two weeks"; and I believe it. They all have all kinds of ideas, and you have to treat them with respect, of course, and you have to let them feel that you are interested in whatever they have. If it is a new scheme for reducing garbage, or whatever it may be, you have to listen to it. An engineer, as a rule, can't stand that kind of a game. Apparently he doesn't want to, he isn't trained that way. He shrinks from publicity, and why? I have tried to reason it out in my own mind and I have come to this conclusion,— I may be wrong, I may be right, but I will give it to you as I have reached it,— that the engineer is given a proposition to work out and he absolutely retires to work out that proposition. I suppose it is fair to say that seventy-five per cent. of the things which engineers work out are never made public, and if they are made public, they are made public by somebody else, some board or some committee. The engineer retires to work out his proposition and then makes his report in writing. I thought for a long time that the trembling and the shaking of my knees when I had to get up before a body of men and make a proposition was purely personal. But I discovered that it was the result of having carried on all my work alone, without the thought of ever having to go before the public to argue or explain its details, and there are a great many men, engineers, who have that same feeling. I never will forget the first time I had to go before a board of directors and explain a report. I had written to them before but had never had to speak to them. And if you will go back you will find that in your college training the same was true; you wrote everything, you never had to speak. I think a great deal of the fault is due to our education, that the educational institutions do not realize the importance of the engineers' being able to approach the public, and it is a detriment and a handicap to the profession.

It has been quite pleasing to find that a great many colleges are now including municipal courses. We have had in Dayton a great many requests from young men to come and study and work with us with the idea of getting the benefit of that experience. One of the training bureaus in New York asked me how many men we could take, and I told him that we could take care of two, with this understanding, that they would give me one student who was not professional and one who was from an engineering school. To my mind, this particular field is opening to the engineer and I desired to make that comparison between the graduates of the two types of schools. But to our surprise we found that while the academic colleges had scholarships that could be applied to such work, none of the scientific colleges had.

There are, all through the American cities, numerous mechanical, civil and electrical engineers who are doing municipal work. The ordinary engineer will not go into office in a city because he feels that under the old scheme there will be a change about every two years (and good old Massachusetts puts them out sometimes every year), and an engineer will not take that risk. But here is a new field opening up which is creating a position for him which is made for him, if he desires to take advantage of it.

We are being called upon very frequently to recommend somebody as a city manager somewhere, and it is pretty hard to pick the material from men who are drawn in municipal work.

If the engineer desires to get into this opening and take advantage of this new territory which is rightfully his, there is going to be, to my mind, a wonderful field. I think it is the opening of a new field for him, and I believe the beginning of a new era for the government of municipalities.

DISCUSSION.

Questions asked and the answers given by Mr. Waite. Also discussion by Hon. James Logan.

Question: What has been done about flood prevention at Dayton?

Answer, by Mr. WAITE: The flood prevention is under a commission — under a flood prevention board, and after considerable study they agreed that the successful plan would be by retention reservoirs. Laws have been drawn and passed by the legislature, and the constitutionality of the bill has been attacked. It has passed into the Court of Appeals and has now gone before the Supreme Court. The engineers are proceeding, however, with their plans for their reservoirs and dams and will have everything ready as soon as the legal end has been disentangled.

Q. What is the function or scope of the Commission?

A. Legislative. It is legislative; it is the policy board, just as a board of directors would be. It designates the policy, passes all legislation, and tells the city manager what he can do. We work together exactly as a board of directors and the president of any large organization.

Q. What are the terms of office of the Commission?

A. Four years. Two are elected every four years, and three every four years — alternate years. The commissioner receiving the largest number of votes is the mayor, who presides over the Commission.

Q. Does it take three times four, or twelve years, to change the policy of the Commission?

A. No. On the first election, two were elected for two years, the two commissioners receiving the least number of votes, so that at the end of two years two more will be elected.

Q. What is your term of office?

A. There is no term of office.

Q. What is the tax rate in Dayton?

A. The tax rate this year was 14.4; next year it is to be 13.6 on a one hundred per cent. valuation.

Q. Do the commissioners receive salaries?

A. Yes, $1 200 a year; and the mayor $1 800.

Q. How much time do they have to devote there?

A. It takes one morning a week, from 9.30 to 12.00, and then of course they go around the city if there is anything of particular importance. Any question of improvement which comes up goes to the Commission, and the Commission refers it to the manager. We investigate and make our report. If it is something of importance, we ask the Commission to go out and look it over.

Q. Do I understand that the heads of the various departments are appointed by the manager?

A. Yes; appointed by the manager, with unofficial approval of the commissioners.

Q. How do you appoint your other subordinates? Are they confirmed by any civil service?

A. Yes. We have civil service. We take them from the list, but it is quite different from the federal form. Under our civil service rules, they put up the entire list. We can select any one from it.

Q. Doesn't that make it rather embarrassing?

A. I don't call that embarrassing.

Q. How do you finance the repaving of the streets? Does that come out of the tax levy?

A. Repairs come out of current revenues and expenses. New improvements come out of assessments. The city bears part.

Q. What part does the city bear?

A. On a street which is being paved for the first time, we assess 98 per cent. The city takes care of the two per cent. and the intersections.

Q. And they stand for it?

A. Yes, sir. We are not spoiled by as much money as you have in this part of the country.

Q. What is the valuation?

A. $165 000 000.

Q. What is the net debt?

A. A little less than six million, $5 763 000.

Q. The city manager is appointed by the Commission. Is he subject to removal by them?

A. Yes, sir. Or by recall of the people.

Q. What method do you use in assessing property?

A. The Board of Assessors.

Q. Is that Board of Assessors appointed?

A. Appointed by the governor of the state.

Q. Then you and your Board of Directors have no power over the assessors?

A. We have no power over the assessing or the tax rate. That is, the assessing is done by the Board of Assessors appointed by the governor, and the tax rate is set by the budget commission. A budget commission is formed for each taxing district. In our district it is comprised of the county auditor, the city attorney, and our mayor. We have two voices against one. That budget commission takes its entire revenue and will first set aside the interest and sinking fund for the debts of the various political divisions, that is, the county, the schools and the city. We have to put our budget before that budget commission and then they apportion what is left to the three divisions. Of course, the state levy is always fixed and has to be met.

Q. How are the expenses of the schools met?

A. The School Board present their budget at the same time that the county and city do, and it is all met out of the one levy.

Q. I understood you to say that the auditor was appointed by the treasurer?

A. By the finance director. There is a finance director who has under him the treasurer, the auditor and the purchasing agent.

Q. Why is the auditor under the same control with the treasurer?

A. I can't see any objection to it, with an outside running check.

Q. How are the expenses of the School Department handled?

A. By the School Board alone.

Q. That is, the School Board is a separate government entirely?

A. We call it a separate political division. We have the four political divisions, the expenses of which have to be met through this budget commission.

Q. Has the mayor any powers outside the Commission?

A. No. He says he is the "speaking member." Of course, the laws of the state require a mayor. The signature of the mayor is necessary on some documents, but he has no more power or authority than the rest of the Commission except he is its presiding officer.

Q. Chairman of the Board of Directors?

A. Not chairman of the Board of Directors, chairman of the Commission.

Q. How are the commissioners nominated?

A. By a petition, two per cent. signers.

Q. Is there any tendency of this form of government to take over the public utilities? Do you think this form of government could run a lighting station, say, as economically as a private company?

A. Of course I will have to say that I think we can, but I hope we won't have to. We have a water-works, and that is enough for the present.

Q. What per cent. of the voting population is necessary for the recall?

A. Twenty-five per cent. of the registered voters.

Q. You spoke of the tax rate. Is that the same on all classes?

A. The same on all classes; there is no classification.

Q. When you selected the first five commissioners, how many were in the running?

A. Fifteen.

Q. You said that the one receiving the highest number of votes becomes mayor. How does that work out on successive elections? I understand that you elected two for two years and three for four years. Is there any change in that?

A. The commissioner receiving the highest number of votes at that election when three are elected, would be the mayor. There is some dispute among themselves whether it is worth the difference in price or not.

Q. How much money are you going to expend on your new water-works?

A. Our plans call for an expenditure of one million in the next two years and two millions in sixteen years.

Q. Can the Commission incur any bonded debt without a referendum of the people?

A. Indebtedness of the city can be 5 per cent. of the duplicate, 2½ per cent. of that the governing body may issue and the other 2½ per cent. has to be issued through a referendum, so in order to avoid using up everything inside of our authority for 2½ per cent. on the large questions we put up for a referendum. Then there are other complications in taxation there. There are two limits of taxation, a ten-mill limit and a fifteen-mill limit. We can't exceed fifteen mills, and out of the ten mills certain expenditures have to be met and the remaining expenditures from the five mills.

Q. What percentage of the voters work for the National Cash Register Company?

A. There seems to be a great deal of jealousy, I find, in Massachusetts, about the National Cash Register Company. I heard in Springfield that the city of Dayton was run by the Cash Register, and I suppose that is your leading remark. I assure you that it is not true.

Our city registration for the state election was 32 000. I find that those proportions here in this part of the country are somewhat startling. In Springfield, last night, I learned that with a population of 100 000 (I think), they have a registration of 16 000. We, with 125 000, have 32 000.

Q. How many voted?

A. Something over thirty-one thousand. The National Cash Register Company employs about five thousand people, a large number of whom are women, and women do not vote in Ohio.

Q. What percentage of the city's yearly income is used in the school department.

A. None of the city's income is used in the schools. The schools this year or next year get about $415 000.

Q. The total taxation is how much?

A. 13.6.

Q. What per cent. is voted for the schools?

A. The schools' proportion out of that 13.6 was 4.16 on $165 000 000.

Q. Was Dayton the first community that had a city manager?

A. No, sir.

Q. How long had the system been in operation before Dayton took it up?

A. Staunton, Va., I think was the first, and they have had it there about four or five years. I think it was in 1908 or 1909. Then Sumter, S. C.

Q. Do you find under the city management that you have decreased the running expenses of the city?

A. Well, I wouldn't put it that way. I will say that we have given them more for their money.

Q. You give them full value for the dollar?

A. Yes.

Q. But you have only been running eleven months?

A. That's all.

Q. Do you see any reasons why that cannot be applied to the larger cities in the country?

A. I can see reasons, yes. I will answer you the way I answered the New York *World*. After I had been in Dayton about forty-eight hours, the *World* wanted to know if I thought it was applicable to a city the size of New York, and I replied, "Yes, if New York is ready to divorce politics from municipal affairs and keep them divorced."

Q. How are the police appointed?

A. By civil service.

Q. By the Commission?

A. By the city manager.

Q. Are there any cities larger than Dayton that have this form of government?

A. No, it is the largest.

Q. Would you be surprised to know that this form of government was sent to two of the leading Boston papers in January, 1908, and refused publication?

A. Was it the Lockport plan?

Q. No, this very plan. Would you be surprsied to know that this plan had been sent to the two leading Boston publications and refused?

A. I am very much surprised.

Q. What has been done with the politicians out there?

A. They are marking time.

PRESIDENT EDDY. — Gentlemen, it is very rarely that the Boston Society of Civil Engineers, and I imagine that it is equally seldom that the Boston members of the American Society of Mechanical Engineers or the Boston Section of the American Institute of Electrical Engineers are honored by having in its audience present or past mayors, and I know you will be interested to know that to-night Mayor Cook of Fitchburg, and very likely during a portion of the evening other mayors with whom I do not happen to be acquainted, were present. I want to trespass on your time just a moment, and I know that you will be well repaid for staying, to present to you a gentleman with whom I have been acquainted for many years. I haven't told him I was going to call on him, but I don't need to. He has had real experience in city work, — Ex-Mayor James Logan, of Worcester, — and has come down here to listen to this address. I know that he is brim full of ideas, and that he really wants to say something.

MR. LOGAN. — I had no thought when I came here of being called on to speak. I came here as a humble learner, and I have learned some things. I have learned that the politicians in Dayton are marking time. And I will suggest that they are only marking time and that we will hear from them later.

It is no easy position to be the mayor or business manager of a city. Being the hired man of 165 000 people like the city of Worcester, for example, is not an easy place, but I want to say to you that, barring newspaper abuse, I never enjoyed a piece of work in my life more than I did this service to the good city of Worcester. I was fortunate in some particulars. I had no political debts to pay and I had no enemies to punish, and be it said to the credit of Worcester that in the four years that I was in City Hall, no man who was prominent in any of my campaigns ever came to me to ask a favor — not one. And after three months hardly any one else came asking favors. They knew where to find me; courteous I tried to be always, and I never lost my temper but twice in the four years. Once was with the manager of one of the public-service corporations. I did lose my temper then, but it produced the result desired in less than forty-eight hours. After I got through being mayor, my experience had not soured me, and when I rode out on a Sunday afternoon, the cows for five miles round didn't give sour milk.

One asset which I highly prize, that I took back into private life, was the friendships I made in political life. I am thoughtful, and sometimes fearful, for the future of this country when so many men like you here (now, put the coat on, for it fits you) neglect your duties and do not go to both the caucus and the polls. You haven't done your whole duty when you simply go to the polls and vote.

If you don't do your duty, this country has seen its best days. You men, engineers, ought to stand in the community where you are located for the highest and best, and do your part to save it.

Just one little experience before I sit down. I think it was the first month after I became mayor, one of the men in the Board of Aldermen much desired a certain appointment. He said, "You understand, Mr. Mayor, that if that don't go that way I shall object and hold up the appointment." "Well," I said, "that is your privilege and your duty, but it is my business to do the appointing and I won't ask you to assume my responsibility; I will take that myself. Having done my duty as I see it, it will be up to you to do your duty as you see it, and I trust that when we get through we will be just as good friends as before, even though we may not agree in this matter." "Well," he said, "you want to remember that I've got some Scotch blood in me." "Well," I replied, "that may be, and it's good blood, and while we are on that subject, let me say to you that mine is *all* Scotch." And there the matter ended.

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PAPERS AND DISCUSSIONS

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DISCUSSION OF THE MECHANICS OF REINFORCED CONCRETE UNDER FLEXURE IN BEAM AND SLAB TYPES.

MR. JOHN R. NICHOLS (*by letter*). — It has been suggested that there ought to be some explanation of the apparent discrepancy between the steel stresses which the application of the principles of statics to a flat slab floor design would lead us to expect and those deduced from extensometer measurements in tests. In the writer's opinion the chief cause of this discrepancy lies in the assumption, commonly involved in the application of statical principles to reinforced concrete structures, that the concrete immediately surrounding the rods is incapable of exerting tensile resistance in a direction parallel to the reinforcement, whereas, in fact, the concrete does act in tension, materially assisting the steel. This opinion is supported by the results of tests on rectangular reinforced concrete beams. For example, Mörsch* presents curves showing that in a beam having 0.4 per cent. reinforcement, a load which, on the assumption of no tension in the concrete, should have caused 16 000 lb. per sq. in. tension in the steel, actually produced less than 3 000 lb. per sq. in., as measured by extensometer. In a beam having 1.0 per cent. of steel, the measured tension was 8 500 lb. per sq. in. for a similar load. The only possible explanation for the low measured stresses in these beams seems to be that the concrete did in fact act in tension.

The following table, computed on the assumption that the concrete acts in tension and follows the same straight-line law of stress distribution in tension that is commonly assumed in compression, gives the tensile stresses in the steel, f_s, and the maximum tension in the concrete, f_t, for loads which, on the assumption of absence of tension in the concrete, would produce a steel stress of 16 000 lb. per sq. in. The depth to the steel is taken as eight ninths of the total depth, as, for instance, in a 9-in. slab, and $\frac{E_s}{E_c}=15$.

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*"Eisenbetonbau," 2d edition (German), p. 101.

TABLE.

p.	f_s.	f_t.
0.001	808	70
0.002	1 530	132
0.003	2 180	189
0.004	2 780	241
0.005	3 330	290
0.006	3 840	335
0.007	4 320	378
0.008	4 750	417
0.009	5 180	455
0.010	5 550	490

Other tests might be cited to support the evidence of the Mörsch tests and the table, to the effect that concrete is capable of assisting the steel through its tensile strength to a marked degree.

The low values given in the table for the maximum tensile stress in the concrete indicate that cracks are not necessarily to be expected in beams and slabs with low percentage of steel and subject to working loads. On the other hand, the tests show that the stress in the steel, as measured by extensometer, remains but a fraction of the stress determined by ordinary computations long after cracks have become visible. It should be pointed out, however, that extensometer measurements do not indicate the stress at any particular point in a rod but only the average over a considerable length, usually eight inches. The stress in a rod at a crack in the concrete may be and probably is much higher than the average over the eight inches of which the crack is the center. Extensometer determinations of the steel stresses in flat slab floors are, of course, equally subject to error from this source.

On the whole, it seems clear that the low steel stresses reported from flat slab tests, so far as they are not due to inherent defects in the method of their estimate, are chiefly due to tension in the concrete in a direction parallel to the reinforcement.

In order to discuss Mr. Turner's paper with fairness, it is necessary first to attempt to state its main thesis as nearly as may be in clear terms. As the writer views it, Mr. Turner's contention, put into plain language, is as follows:

When tensile reinforcement in concrete consists of two bands of rods at right angles as in a flat slab floor, the concrete interacts between the two bands in such a manner that the tension in each band relieves or reduces the tension in the other.

Mr. Turner supplements this with the assertion, necessary for its validity as a factor in flat slab floor design, that the tension in the concrete incidental to the interaction mentioned is " indirect," and, unlike " direct " tension, is not interfered with in its effectiveness by cracks.

The interaction of the concrete between multiple bands of steel rods in tension is best studied by considering the simple case of two bands, band *A* and band *B*, at right angles, both bands equally stressed in tension. Suppose that the unit stress in each band is f_s (pull in each rod divided by the cross-section). Assuming for the moment that the rods are not subject to lateral tension or compression upon their surfaces, the unit strain or extension of the rods is $\frac{f_s}{E_s}$.

The unit tension in the concrete on sections at right angles to the rods let us call f_c. If this tension were acting only in the direction of band *A*, the unit tension in that direction would be $\frac{f_c}{E_c}$, and, noting that the extension of the concrete is the same as that of the embedded steel, we could then write

$$f_c = f_s \frac{E_c}{E_s}.$$

But in the case we are considering the concrete is subject also to equal stretching in the direction of band B which induces a lateral contraction in the A direction measured by Poisson's Ratio, R. Then the actual unit extension in the concrete is only $\frac{f_c}{E_c}(1-R)$. Assuming this equal to the unit extension of the steel, we have,

$$f_c = f_s \frac{E_c}{E_s} \cdot \frac{1}{(1-R)}.$$

The effect of multiple way reinforcement in a concrete slab as distinguished from one way reinforcement is thus merely to stiffen the concrete somewhat. For example, if we may take R as 0.1, a commonly accepted value for concrete, and $\frac{E_s}{E_c}$ as 15, we find that in a flat slab $f_c = \frac{f_s}{13.5}$, whereas in a beam we would have $f_c = \frac{f_s}{15}$. The concrete in certain portions of a flat slab floor is thus capable of assisting the steel in tension about 11 per cent. more than the same concrete in a beam or one way slab, — always provided, however, that the concrete does not crack. It is probable that this augmented assistance is actually rendered between cracks, but where cracks occur it would still seem desirable to provide steel enough to take the whole tension without assistance of any kind.

Returning now to the question of lateral stresses in the steel rods, suppose the concrete is able (and willing) to exert on the surface of the rods a lateral tension as high as 500 lb. per sq. in. This would induce a longitudinal contraction equivalent to that produced by a compression of $0.3 \times 500 = 150$ lb. per sq. in., taking Poisson's Ratio for steel at 0.3. Additional longitudinal tension of 150 lb. per sq. in. would then be required to restore the rods to their original extension.

Assuming, now, what is probably untrue and is at best a mere assumption open to grave doubt, that the criterion of failure of the rods is unit extension rather than unit stress, we may safely stress rods embedded in the above "supposed" concrete to 16 150 lb. per sq. in. instead of the 16 000 commonly permitted.

To sum up, the interaction of the concrete between bands of reinforcement which takes place in portions of a flat slab floor renders the concrete some 11 per cent. stiffer than it would be if stretched in one direction only, and perhaps at the same time 11 per cent. stronger. It then gives 11 per cent. more assistance to the steel through its tensile strength, if it does not crack. In addition, perhaps the strength of the steel is increased by something less than one per cent.

It will possibly occur to some that the meager results here extracted from the "interaction of the concrete" are hardly sufficient to explain Mr. Turner's mushroom designs. However that may be, the writer, with all due deference, would like to be shown the process by which more can be extracted.

So far as the writer is aware, Prof. H. T. Eddy is the only person who claims to have justified Mr. Turner's designs of flat slab floors on a theoretical basis. Mr. Eddy's success, however, is due not to consideration of concrete interaction as above set forth, but to his outright assumption that the reinforcement of a flat slab floor is equivalent to a uniform sheet of some kind of homogeneous substance as strong as steel in tension and possessing a Poisson's Ratio of 0.5. He ignores the fact that at least twice the weight of steel in crossed strips or rods is required to provide the same strength in all directions as a homogeneous plate. On the basis of such assumptions almost any design, however inadequate, could be given an apparent justification.

Mr. Turner states in his paper the well-known fact that in a beam with uniform loading the positive bending moment at the center plus half the sum of the negative bending moments at the supports is equal to $\frac{1}{8}WL$. Now, any portion of a flat slab floor for which the outer forces can be determined may be considered and treated as a beam, and if we select the boundaries of such a beam so that the side edges are parallel and free from vertical shearing stresses the load will be uniformly distributed along its length if the floor load is uniform as is usually assumed.

Fig. 1 represents an interior panel of a uniformly loaded flat slab floor of indefinite extent. The portion of the slab marked out in heavy lines is a beam of which *A* and *B* are the sides. These sides are on the center lines of the columns and the vertical shear thereon is evidently zero. *C* and *D* are the ends of the uniformly loaded beam the span of which is l_1. The writer considers, by the way, that the proper value of l_1 is $L_1-\frac{2}{3}D$.* We may then write

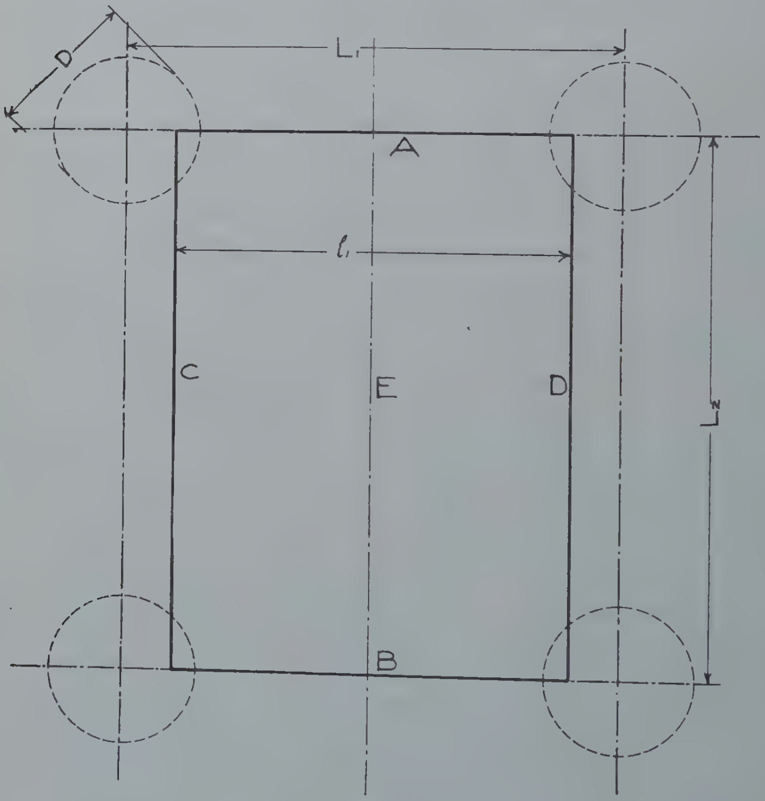

FIG. 1.

$$\frac{M_c+M_d}{2}+M_e=\frac{wL_2l_1^2}{8},$$

where *w* is the total load on the slab per sq. ft. Assuming, as we ordinarily may for an interior panel, that $M_c = M_d$, we may then write

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* Trans. Am. Soc. C. E., Vol. LXXVII, pp. 1670–1673 and 1735.

$$M_c + M_e = \frac{wL_2 l_1^2}{8}.$$

There is no escaping the conclusion that, unless tension in the concrete is to be relied upon, steel must be provided in the top of the slab at *C* and *D* (of course, mainly near the columns) and in the bottom of the slab at *E* in sufficient quantity to take care, in the aggregate, of these bending moments, whatever may be the proportion in which any particular designer may wish to distribute it between the three locations. In the case of rods crossing the lines *C*, *D* and *E* at right angles, the full strength is to be considered in determining the moments of resistance, but rods crossing obliquely are to be valued at the components of their allowable strength normal to these lines.

Similarly, steel must also be provided to take care of the positive and negative bending moments of the slab considered as a beam spanning in the direction of the line *E*.

If steel is not provided to take, at allowable unit stresses, the whole tension incidental to these moments, it is clear that the concrete must assist in direct tension or the steel be overstressed.

DR. HENRY T. EDDY *(by letter)*. — The last two or three sentences of Mr. Worcester's letter argue apparently that because it is not clear how the tensile stresses in crossed belts can interact in the matrix of a flat slab in such a manner as mutually to diminish the stress of each belt in the other, no such thing exists. The correct attitude of mind would seem to be to inquire whether the alleged phenomenon exists, and if so, then to attempt to discover its explanation. Now no one would deny that circumferential stresses occur in a thin metal dome and that by their action it is enabled to carry loads far in excess of the sum of the loads which could be supported by all its meridianal segments acting independently, and that these circumferential stresses take up and hold in equilibrium the radial horizontal thrusts induced by the load and acting at right angles to the circumferential stresses. Moreover, they are neutralized at the different levels in the dome where they arise and are not propagated to the bottom of the dome as they are when each segment acts as an independent arch.

Neither will any one conversant with the action of an extended thin plate supported on crossed girders or rows of columns in rectangular array deny that it develops, under load, circumferential tensions about the supports and about the panel centers that enable it to carry much greater loads than the aggregate of all the loads it could support when it resists flexure simply as a beam or as a number of beam strips. If such be the fact, as it is, then no beam strip theory will apply to such a structure or furnish principles for its correct design. In the plate, as in the dome, the circumferential stresses about panel centers prevent the propagation of moments and stresses radially toward the supports by holding the radial stresses in equilibrium, thus making the horizontal stresses in this part of the plate self-contained and thus reducing to a considerable extent the amount of metal which would otherwise be required. A similar action occurs about the supports. The reality and surprising excess of strength and stiffness of a plate over a beam can be very readily demonstrated by a very simple experiment.

Take a sheet of ordinary 8-in. by 11-in. writing paper, which will not support its own weight as a beam between supports 5 in. apart. Lay it upon four equal spools 5 in. apart and place two light strips of wood across the sheet at mid-spans of the spools in the form of a cross. The paper will support a load of several ounces in this manner, thus exhibiting a phenomenon entirely different from beam action, which may be properly designated as plate action. It exceeds beam action many fold.

Now a properly reinforced flat slab imitates plate action sufficiently to take advantage of the same kind of circumferential stresses. It does more than this because it introduces the reinforcement in larger amounts where the stresses are more severe and in less amounts where not needed, thus effecting economy as compared with a uniform plate. That the flat slab does really imitate plate action in the manner just described is the only possible explanation of the results of innumerable load tests of flat slabs in which slab deflections have been observed as well as the results of the few extensometer tests which have been published. It is only on this basis that any one has attempted to discuss the mechanics of slabs to obtain rational formulas in any accordance with tests.

A circumferential cantilever, as the term is employed in Mr. Turner's paper, is that part of a flat slab over and around a support where actions are called into play by negative bending moments like those developed in a thin metal plate when similarly situated. The difficulty which Mr. Worcester experiences in seeing how it is possible that reinforcement well disseminated through the concrete can cause the slab to act like a plate is due to an insufficient realization of and failure to recognize the important and dominating rôle which the concrete plays in binding the entire fabric of the structure together so reliably that it will act as a unitary monolithic sheet in which radial and circumferential stresses occur much as they would in a homogeneous plate regardless of the directions of the various reinforcing rods in case they are sufficiently disseminated. He would perhaps be willing to admit that for very small loads this might possibly be true, but not for working loads. What we assert is that it still holds up to double the working load, when the elongations of the steel show maximum unit stresses up to 20 000 lb. Under these circumstances the statement does not hold which Mr. Worcester evidently regards as axiomatic, viz., "The total tensile stress cannot exceed the total capacity of the reinforcement," because by the words "total tensile stress" is meant the tensile stress computed on the principle of moments as found in beam structures. It would be just as logical to insist that a metal dome, which is a self-contained structure, must necessarily exert the same horizontal thrust as an arch. Tensile stresses in crossed reinforcing rods coact through the concrete in such a manner that each reduces the intensity of the other, but not in such a manner as is assumed by Mr. Nichols in his calculations. The coaction is by means of the bond shear on the surface of the rods which causes lines of stress in the concrete both of tension and compression in directions at 45 degrees with the rods, and not by direct lateral tension in the concrete in directions perpendicular to the rods. These are two entirely different kinds of actions and have nothing in common, as will be seen by reference to "Concrete-Steel Construction," Part I,* pp. 121–133. It is well known that the bond in slabs remains intact under loads far beyond tensile loading, and is consequently dependable whether we regard that as due to the indirect tensile stresses at 45 degrees which tie the crossed rods together, or to the indirect compressive stresses by which the crossed rods mutually support each other. However that may be, the reality and dependability of such coaction is unquestionable.

It does not appear that the discrepancy between the statical moments of the applied loads and the moments of resistance of the reinforcing steel can be largely accounted for by considering the tensile resistance of the concrete acting parallel to the reinforcement, as is the opinion expressed by Mr. Nichols. While the facts adduced in support of his opinion are incontestable, they are entirely inadequate to establish the validity of any such explanation of this discrepancy, because the discrepancy still exists at loads so large as to preclude the possibility of any large assistance from concrete in direct tension. The phenomena which are under discussion have reference in general to observations at double the design load with unit stresses in the steel of 16 000 lb., and more where direct tensile stresses in the concrete cease to be of material assistance to the reinforcement. Moreover, it is questionable whether Mr. Nichols' argument respecting the unreliability of extensometer measurement where tension cracks exist in the concrete is valid, because just such measurements as he objects to as unreliable have shown excellent agreement between computed and observed steel stresses in heavily loaded beams.

Mr. Nichols states that "any portion of a flat slab floor for which the outer forces can be determined may be considered and treated as a beam," and he evidently regards it as a self-evident truth. Such, however, it is not, as both theory and test show its incorrectness. Just as well say that a dome may be considered and treated as an arch as to say that a plate or a slab may be treated as a beam. To be sure, it can be done on paper, and has been done, but of what use is it to do it? No results even approximately correct can be arrived at by the process. The first requirement of applied mechanics is that the assumptions used shall include the predominant phenomena. Beam theory will not do this for slabs. But beam theory is evidently so ingrained in the warp and woof of engineering mathematics that it is perforce used whether it applies or not. It is the old question of whether the world moves or not in a new guise.

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* Eddy and Turner, Minneapolis, 1914. This book, the gift of Mr. Turner, may be seen at the library of the Society. — Ed.

It may be observed that in this and other discussions on slabs those engineers who have had occasion to know the facts at first hand by actual test and construction are perfectly aware that there is a wide discrepancy between any deductions from beam theory and floors as actually constructed, and so hesitate somewhat to express definite opinions on theoretical questions at variance with those facts. Many others seem, however, to have no such hesitation.

Mr. Thompson has taken occasion to refer in his discussion of this paper to my recent paper on "Steel Stresses in Flat Slabs,* in which all the available extensometer tests of flat floor slabs, five in number, were compared with the values computed by my formulas, both as to steel stresses and deflections. In a previous paper,† the results of a comparative test of two experimental slabs were given, one of them built on the mushroom type. This last and two of the five preceding slabs were of the mushroom type and the other three of similar design. The stresses and deflections observed at test load showed, as the result of scores of measurements, astonishing agreement between the computed and observed results, as any one can see by examining the papers referred to. At working load, however, there was a single rod showing an abnormal unit stress of 22 400 lb. against a computed maximum stress of 19 500. The reason for this divergence was perfectly well known and clearly stated, but on the basis of this single observation Mr. Thompson asserts that stresses obtained by my formulas did not agree within 50 per cent. with the actual stress, a palpable misstatement which any one who will take the trouble to read the entire discussion referred to will find inexcusable, for Mr. Thompson omits all reference to the extensive additional data from another test which was presented by me in my closure of the discussion to which he refers, which showed conclusively that his contention as to the inapplicability of my formulas was without foundation. Nevertheless he has here repeated his original statement after it has been shown to be without any sufficient foundation. The observed stresses and deflections at test load were in good agreement with computed values.

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* Trans. Am. Soc. C. E., Vol. LXXVII, pp. 1338–1453 (1914).

† *Engineering News*, Vol. 69, pp. 624–628, March 27, 1913.

Mr. Thompson further asserts twice in one sentence that my formulas were based upon the test to destruction of the experimental slab above referred to. There is no foundation whatever for this assertion and it is not in accordance with the facts, as any one will become convinced who will follow their deviation from the general differential equations of plates as given in my books. Not only is the statement incorrect, but it shows that Mr. Thompson does not himself understand how they are established. They are not based on any tests whatever any more than ordinary beam theory is based on tests. The theory is developed, and then since tests show a good agreement with its deductions, the theory is confirmed thereby. The same is true of the slab theory advanced by me. It was applied to the test results of the experimental slab, just as it was to other tests. The remarkable thing about it is that these theoretic formulas which have been compared with numberless other tests should have been found to be in such good agreement with that test also, in which stresses and deflections were observed under a much wider range of loads than usual, and in a slab which was not an integral part of a continuous floor, but under circumstances which Mr. Thompson criticises so adversely. This would seem to be an argument to confirm our confidence in the wide applicability of these formulas rather than otherwise.

Whether Mr. Thompson regards the stresses in the Northwestern Glass Co. slab as excessive or not has nothing whatever to do with the question at issue. The question is this: Do the concordant mathematical theories and formulas developed by Mr. Turner and by myself show a good accordance with experiment, and are they founded on correct mechanical considerations or not?

It is not a fact that there is any material divergence between test results and those computed by us, although Mr. Thompson has attempted to assert otherwise. That question may be safely left to any competent unbiased reader. The other question as to the cogency and correctness of the mechanical considerations adduced as proof of the formulas, is the one open to discussion. Professor Johnson, while he entirely rejects the reasoning proposed in support of them, hazards the opinion that if they are in agreement with test, "they may be in essence merely empirical formulas." Considering the question from the standpoint of the probabilities in the case, it can be said that a single theory which embraces at once both stresses and deflections throughout the slab would have infinite chances against its agreement with a wide range of tests. It might be possible to obtain an empirical formula for deflections and an independent one for stresses when it would be impossible to derive either from the other. On the theory of probabilities it will consequently be necessary to find some other explanation than that given by Professor Johnson.

MR. C. A. P. TURNER (*by letter*).* — The fact that the writer's effort to treat in some detail the mechanics of reinforced concrete under flexure in beam and slab has aroused the interest indicated by this discussion is gratifying indeed. As a designer of structural steel for many years, the writer fully appreciates the enigma presented by reinforced concrete to any member of the profession who has tried to consider its action by the usual mode of reasoning which is adapted to structural steel but not to concrete.

Mr. Worcester's criticism of the writer's effort as a labored one is undoubtedly justified, since the writer's work has been along the line of originating new ideas and putting them to commercial use rather than in presenting them to others in the finished style of a pedagogue.

Since presenting the paper under discussion, the writer's ideas of the mechanics of bond shear have been elaborated more fully with the assistance of Dr. Eddy in a treatise on the elementary principles of concrete-steel construction,* a copy of which is presented to the Society herewith for the convenience of those who wish to pursue the matter further than the limits of this discussion will permit.

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* Author's closure.

Mr. Martin has answered Mr. Worcester as to the equality of radial and circular stress in the circumferential cantilever with square panels. The mathematical proof will be found in the treatise above mentioned in Chapter IV.

Some ten years ago the writer found it necessary to determine what the deflection of continuous beams and slabs would be under test loads from two to two and one-half times the magnitude of the working load, because building departments and engineers demanded some guarantee of the specific limits of deflections in the work he was designing. In the course of five years of continuous, careful observation of such deflections and tabulation of the results, not only in work designed by himself, but in that designed by others, and on different systems and with no preconceived ideas or theoretical prejudices to warp his judgment, the writer derived the following formula, published by him in 1909:

$$\Delta = \frac{Wl^3}{7\,000\ (1.414)^3\ \Sigma A_s h^2} \quad \text{.........} \quad (1)$$

for a square continuous panel supported on columns, and

$$\Delta = \frac{Wl^3}{5\,000\ \Sigma A_s h^2} \quad \text{.........} \quad (2)$$

for the deflection of the continuous beam under test.

In formula (1), l is the diagonal span of the square panel, and in (2), l is the span of the beam center to center of supports respectively; Δ, the deflection; W, the total load; ΣAs, the right cross-section of the steel at mid-span running from support to support; h, the distance from the center of this steel to the top of the slab.

The relation between the two formulas shows that the deflection of the continuous beam is 3.959 times as great as the deflection of the continuous slab supported on posts, while the theory of work, taking into consideration the difference in the mechanics of the two structures, makes one deflection in round numbers four times the other, an excellent agreement of theory and experiment well within the limits of errors of observation.

---

* "Concrete-Steel Construction," Eddy and Turner.

The knowledge of the profession at large as to the deflection of concrete floors at the time this five-year investigation was finished may be illustrated by the writer's experience in furnishing the design for the John Deere Plow Company building at Omaha, in 1908. At that time the writer's standard flat slab construction was the only one known commercially, and notwithstanding the fact that he had up to that time erected several scores of buildings and published numerous general articles describing them, the construction was new to the profession. The owners of the building consequently called in Professor Talbot of Illinois to report on the construction. After investigating a number of these buildings, such as the heavy stock house for the Hamm Brewing Company, the great Lindeke Warner building, and others, Professor Talbot was satisfied that such a construction could be put up to carry the loads safely. In his well-known broad-gaged style he made no pretense of being able to compute its strength or deflection, but simply advised the owners to get a bond from Turner for fifty thousand dollars, guaranteeing both its strength and deflection under load. The writer had stated what the deflection would be, and he was asked to guarantee exactly what he figured it to be. The writer furnished the bond, the building was tested, the deflection was in accordance with the guarantee and no injury to the construction was apparent nor any overstress in evidence under a load of double the working load.

In the following year these formulas were given to the public. Since their publication, hundreds of tests have been made which confirm their substantial accuracy.

For the rectangular panel in which L_1 is the long side and L_2 is the short side, (1) reduces to the following approximate formula

$$\Delta = \frac{WL_1^3}{7\,000\, \Sigma A_s h^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

A general and somewhat more accurate empirical formula may be written covering both the continuous beam and the continuous four-way slab supported on columns either with square panels or with rectangular panels, as follows:

$$\Delta = \frac{Wl^3}{\left[4\,990 + \sqrt{10^7\,(l - L_1)}\right]\left(\frac{l}{L_1}\right)^3 \Sigma A_s h^2} \quad \cdots\cdots\cdots \quad (4)$$

This formula, when $l = L_1$, in other words, when we have parallel reinforcement, reduces to substantially the previous empirical formula (2) for continuous beams. When $L = 1.414\,L_1$, it reduces substantially to formula (1). When L_1 is greater than l and L_1 is less than $1.25\,L_2$, the general formula gives a value substantially the same as (3), but gives deflections increasingly greater as L_1 becomes greater than $1.25\,L_2$. This formula furnishes a convenient method of investigating the effect on the deflection of varying the angle at which bars cross at mid-span. This general formula agrees substantially both with the theory of work and with experimental results, and furnishes a ready means of investigating the effect of the differences in obliquity of the angle of crossing of diagonal belts upon the deflection.

The reason for this marked difference in the relative deflection of rectangular and square panels is made clear by the method employed in arriving at the ratio of four for a square panel as compared with a beam. In the square panel the circular stresses do not affect the vertical geometry of the slab, while in the rectangular panel the circular lines of principal stresses in the square panel become elliptical and those in the direction of the major axis have the marked influence on the vertical geometry of the slab indicated by the formula.

Confusion of the deportment of square panels and rectangular panels and the failure to distinguish between the operation of wide belts coacting by bond shear with the operation of narrow belts which cannot so act accounts for the erroneous views of many of the profession regarding slab action.

In case $l = L_1$, (4) reduces to the continuous beam formula (2) and represents the case of cylindrical curvature, but when the rods are placed normal to l under this kind of curvature no coaction is possible.

Mr. Worcester is thus in error as to the essential condition of slab action, which is double curvature and not cylindrical curvature. The maximum efficiency occurs when this double curvature approaches spherical curvature. He badly confuses shears and indirect tensions. Horizontal bond shear must remain or act in the direction of the length of the rods, and if acting upon elastic concrete, doubles the efficiency of the rod. Indirect tensions from shear, as Rankine shows, act at 45 degrees to the shearing force and are not parallel to the rod.

Professor Johnson grudgingly admits that some of Turner's structures are satisfactory and that the Turner formula may agree closely with observed deflections and steel stresses, but being founded on experiment (the theory of work not impressing him with favor), they are a kind of rule of thumb production not to be compared from the scientific standpoint with the misapplication of the principles of statics leading to results agreeing with no known experimental evidence, which if the writer correctly understands his position is advocated by him and by Mr. Nichols.

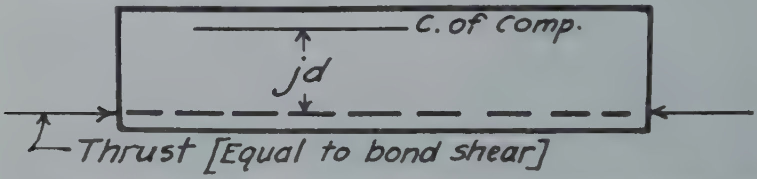
Let us examine the assumed correctness of this reasoning supposed to be based on the inexorable logic of statics. Every known physical and mechanical process in the universe must obey the fundamental law of the conservation of energy. The deflection of a slab under load is a process whose mode of operation consequently conforms to that law. The principles of statics stand upon the *à priori* presumption of the truth of the law of the conservation of energy, and any deductions or applications of those principles apparently at variance with this law are necessarily erroneous and incorrect at some step.

Messrs. Nichols and Johnson would apparently reverse this relation and cast doubt upon the mathematical result worked out by applying the law of conservation of energy under the untenable notion that the law of conservation of energy depends for its validity upon the principles of statics rather than the reverse.

If this fundamental law of mechanics leads to conclusions contrary to those arrived at by Messrs. Nichols and Johnson by statics and its results harmonize with experimental determinations, it is obvious that while there may be nothing wrong generally with the principles of statics, yet through lack of experience in the application of these principles Messrs. Johnson and Nichols have fallen into serious error.

A fundamental principle of statics cited by Sir Isaac Newton in his " Principia " is that action and reaction must be in equilibrium if there is not to be accelerated motion. Hence in the concrete beam with rods in the bottom the steel stress developed by the total horizontal bond shear is equal to the pull on the rod.

To the extent that the concrete behaves as an elastic material this total shear may, for convenient consideration, be regarded as a thrust applied to the concrete in the line of the rod at the bottom of the beam.



The manner of distribution of this thrust demands attention. Since it produces the same horizontal shearing deformation of the concrete as that caused by the bond shear which for convenience it is supposed to replace, it evidently decreases along this line from the ends of the beam where it is greatest to mid-span where it vanishes. This thrust acts with the lever arm *jd* about the centroid of compression at mid-span, and forms a couple with part of compression acting through the centroid of compression at mid-span to carry part of load on the beam. This thrust it is which prevents the lower part of the beam from elongating to such an extent as to preserve the end right sections of the beam at right angles to the neutral axis after flexure. The pull of the rod is differently distributed from this thrust, being greatest at mid-span and zero at the ends of the beam where the bond shear is greatest and where the equivalent bond shear thrust is assumed to be applied.

Now the total tension in the rods at mid-span is equal in amount to the thrust just considered because there is no way for the tension at mid-span to have been dissipated and reduced to zero at the ends of the beam except by the bond shears acting on its surface. The arm of the steel tensions is *jd* also, hence the moment of the tension in supporting the load is the same as that of the bond shear so long as the concrete acts as a fully elastic material.

Hence without calling upon direct tensile resistance of the concrete, we see that before the concrete yields in a plastic manner or cracks, the laws of statics require that the steel stress multiplied by *jd* be not greater than half the external moment of the applied load.

Rankine shows that a shear is equivalent to a tension and compression at 45 degrees thereto. Accordingly these indirect stresses of tension and compression respectively form two paths through the web or body of the beam by which the sum of the tensions equals the sum of the compressions above and below the neutral plane respectively.

Now these paths are of equal rigidity during the elastic deformations of the concrete in tension, but as soon as plastic yielding of the concrete occurs, the two paths are no longer of the same rigidity and more and more of the load travels through the path of the indirect compression. But in the mean time the energy stored by indirect tensions is dissipated by the inelastic yielding of the concrete and the static balance of stored potential energy of the internal work of deformation no longer equals the external work of the load and further motion must result until this balance is restored. (See Clapeyron's Theorem, in the work of Lamé on the Mathematical Theory of Elastic Solids, 1866.)

Without going into the molecular physics of the transmission of force through mass it may be well to consider the state of the case where the concrete has cracked at intervals in the tension side of the beam. The indirect tensions tend to rotate the separated segments vertically in a manner furnishing little rigidity and tending to disrupt the beam. The 45-degree compressions, on the other hand, are opposed by compressions from the upper zone arching over and holding them in equilibrium by presenting a relatively rigid resistance.

In this the beam and the slab differ. In the mushroom slab the rotating tendency from bond shear is predominantly lateral rather than vertical with the mass of the slab to oppose such rotation, hence these resistances do not disappear until the final disintegration of the floor structure. This will be apparent from the laws of bond shear stated in the paper and the diagrams of these forces in Chapter III of " Concrete-Steel Construction " by Eddy and Turner.

The issue between Mr. Nichols and the writer may be summarized not as Mr. Nichols has misstated it, but as follows:

Mr. Nichols asserts that the resistance other than that accounted for by the steel must be absorbed by the concrete through a property inherent therein or as a resistance which it possesses previous to embedment and apart from the steel. Turner undertakes to prove that the concrete *per se* possesses no property capable of supplying this resistance until the steel is imbedded therein and bond shear is brought into action as a new element in the load-carrying mechanism.

Turner tries out the question by experiment. Nichols and Johnson are content to believe they possess the intellectual acumen to arrive at correct results by reasoning based on assumption and without recognition of the facts which compel taking account of the evanescent character of the resistance furnished by the assumed direct tensile strength of the concrete, which resistance is known to disappear in the beam under heavy loads but which remains intact and operative in the continuous slab under heavy as well as light loads.

At this point it is well to observe that Mr. Nichols considers that the direct tensile resistance of the concrete in the continuous slab on columns is increased 11 per cent. above its action in beams, and with 11 per cent. increase in effectiveness, he would account for the 300 per cent. increase in stiffness. This would seem to strain the imagination beyond the india rubber limits of its elasticity.

That concrete does have a small value in direct tension is true. This value enables the concrete to shrink in hardening about the steel, thereby furnishing a reliable bond, and this bond supplies, as we have pointed out, the element of resistance that in a large measure is confused with direct tensile resistance. On the other hand, were the assistance to the steel brought about by direct tensile resistance of the concrete, the concrete must possess tensile resistance several times as great as has ever been discovered by experiment. This fact makes impossible the erroneous explanation offered by Mr. Nichols.

Mr. Nichols cites tests from Mörsch to show that low steel stresses are accompanied by some small direct parallel tensions in the concrete, but he shows utter unconsciousness of the existence of the two dominating and inescapable actions of the embedment which entirely overshadow in their ultimate effect the direct tension to which he refers. These actions are those of bond shear brought about by the shrinkage grip of the concrete on the reinforcement and the casting stresses resulting from the chemical process of hardening. Without the horizontal bond shear, beam action of the reinforcement is an evident impossibility. Hence it is a double absurdity to omit these two principal actions and ascribe their effect to direct stresses which vanish under heavy load.

The hardening of concrete is a chemical process generating heat which expands the steel as the bond is in process of formation. This condition which is followed by the subsequent contraction of the steel induces initial tensile stresses therein of considerable magnitude. These two circumstances largely explain the deportment of newly cast beams under light loads and negative the exaggerated idea of the value of the direct tensile strength of concrete relied upon by Mr. Nichols to substantiate his position. These circumstances further limit the extent of the assistance of the direct tension to ten or fifteen per cent. for light loads and little or nothing for heavy loads. The data furnished by Mr. Nichols are too fragmentary to furnish any basis for determining the amount of the casting stresses, and any sufficient basis for this would require a statement of the temperature at which the cement itself was stored before mixing, the temperature of the water, the temperature of the aggregate and the temperature conditions during the hardening process. Shrinkage stresses may range anywhere from a few hundred pounds to several thousand pounds per square inch on the steel; every practical builder finds evidence of this in course of the removal of forms at different periods of the year.

This discussion discloses also the practical error made by Mr. Nichols in his assumption that only an unbelievably great and unheard-of direct tensile strength of concrete can possibly account for the experimental evidence cited.

Application of the proposition of Lagrange, known as the principle of least action, with which Messrs. Johnson and Nichols are undoubtedly familiar, would condemn their explanation as erroneous in the light of another and possible one involving lower stresses in the concrete. That this is the case may be readily shown by figuring the intensity of the indirect tensions and compressions as compared with the direct tensile resistance which Mr. Nichols arrives at. The one would be only about 15 per cent. as great as the other.

The impropriety and improbability of supposing as a fact that concrete can exhibit the marvelous property of a uniform modulus of elasticity in tension up to and beyond any known value for its ultimate strength in direct tension is a point in Mr. Nichols' theory which he fails to explain and makes no mention of in advocating its possibility.

The confusion of what the writer actually did say with his own misunderstanding of it accounts for Mr. Nichols' subsequent amusing computation of lateral tension on the rods and Poisson effect of 11 per cent. for the concrete to account for a known increase in stiffness and strength of 300 per cent. over that of a continuous beam.

The writer having explained that the Poisson ratio used by Dr. Eddy is neither a property of the steel nor of the concrete, but merely a useful coefficient of the efficiency of the lateral action of bond shear, Mr. Nichols gratuitously assumes that the Turner analysis by the theory of work based upon the law of conservation of energy is dependent upon assuming such a coefficient. Dr. Eddy used such a coefficient in his method of computation by considering the equilibrium of the infinitesimal elements of the slab, whereas the writer, attacking the problem from the theory of work, does not need such a coefficient, although he arrives at concordant results to those of Eddy and those of experiment.

Mr. Nichols presents a kind of imitation beam formula for the continuous slab, making the moment apparently a function of width rather than length in a rectangular panel, but even with this illogical modification it is impossible to account for the wide difference in action between the beam and slab covered by the writer's empirical equation (4) representing the experimental results.

In process of hardening concrete shrinks about the metal embedded therein and tensile stresses result from this shrinkage, leaving the concrete not only reduced or honeycombed in section by embedment of the steel, but greatly reduced in strength by the shrinkage tensions which furnish bond shear resistance. Accordingly the direct tensile resistance is almost eliminated by the crossing of rods about the column head and to a less extent at mid-span, and this resistance is thus reduced far more nearly to a negligible quantity in the continuous slab than in the continuous beam.

Professor Johnson erroneously refers to the writer's empirical formula for the weakest section with his standard form of construction as applying to the section where the greatest moment is to be supported. The weakest section is determined not by the maximum moment to be borne, but by the maximum unit stress. The practicing engineer would not confuse the two, though it is quite natural for the casual reader not actively engaged in practical construction so to do. The section to which this formula applies is mid-span of the direct belts and a line joining these sections at the diagonal and at the edge of the diagonal reinforcement.

Mr. Thompson would infer that the strength of the Turner floor is exhibited with only one panel loaded. Had he seen a warehouse, designed for 250 lb. per sq. ft., carrying a solid load of sugar fifteen to seventeen sacks high with no aisles, for three months, he would revise his conclusions. The writer naturally protested, but the building had performed the service and the load was to be soon removed.

Mr. Thompson's criticism of the test of the slab to destruction is of interest in view of the fact that it certainly did not have the benefit of continuity, which he says vitiates the test results of a single panel.

Mr. Thompson is somewhat hypercritical and very hard indeed to satisfy. If you test four panels you have made a mistake; it ought to have been one because four panels give a balanced load. If you test one, the results are surely vitiated by continuity. If you saw off the continuity, as in test of a panel to destruction, there is some imaginary objection, such as that you have designed capitals of all sizes and shapes, put them in or left them off, to suit the whim of the architect, and according to the critic a microscopic variation of the cap renders all valid conclusions impossible. Nevertheless, the practical builder puts up all kinds, guarantees their strength, and they give satisfactory service wherever the work is executed with ordinary care. Further, it may be remarked that with all the objections of misapplied statics that have been urged against economical, continuous mushroom flat slab floors, they have never yet been known to tumble down on the heads of the workmen putting them up, even when the workmen have, as has often happened from inexperience, removed the forms from but partially hardened concrete.

That concrete subject to restraint will deform in a plastic manner is well shown in the tests of Woolson cited by Homer Reid, in his "Reinforced Concrete," page 390, and those of Considère as well.

In the beam or slab a considerable degree of restraint is furnished against cracking by the steel embedment, but to assume, as do Messrs. Nichols and Johnson, that concrete when it is being plastically deformed in tension can furnish the resistance to strain per unit of deformation that it does under far lower forces producing true elastic distortion is illogical in the extreme.

The final and most conclusive objection to the explanation by means of the direct tensile resistance of concrete is found in the experience of the builder in nearly or entirely eliminating this direct tensile resistance by a bulkhead or splice in the slab at mid-span. With this bulkhead the deportment of the slab differs only slightly from the slab without the bulkhead.

Perhaps a more exact method of eliminating this direct tensile resistance would be to cast a thin plate of metal properly coated with paraffine in a small or experimental beam, thus cutting off fully the tensile zone at mid-span. Then the beam without any direct tensile resistances acting with a lever arm *jd* about the centroid of compression would exhibit the marked characteristic of steel stresses too small to balance the external moment of the load. In such an experiment Messrs. Johnson and Nichols will find a complete refutation of their conception of the mechanics of the beam, just as the practical worker in the field of concrete construction has found in thousands of tests a similar refutation by the bulkhead splices used by him in his every-day work.

Concluding my remarks on the utility of direct tension as a dependable element of resistance in bending, I have discussed this more at length from the theoretical and experimental standpoint in the October Proceedings of the Canadian Society of Civil Engineers, in which I discussed tests of concrete slabs to determine the nature and dependability of this element in continuous panels.

Mr. Bryant's frank discussion is of interest. Mr. Martin has answered his somewhat mistaken idea as to the deportment of the standard mushroom design properly executed. Mr. Bryant does find, however, like most skeptics as to the strength manifested by this type, that it is surely present under severe test, and this unexpected finding leaves him with the honest feeling of uncertainty as to his ability to account therefor on any theory hitherto published.

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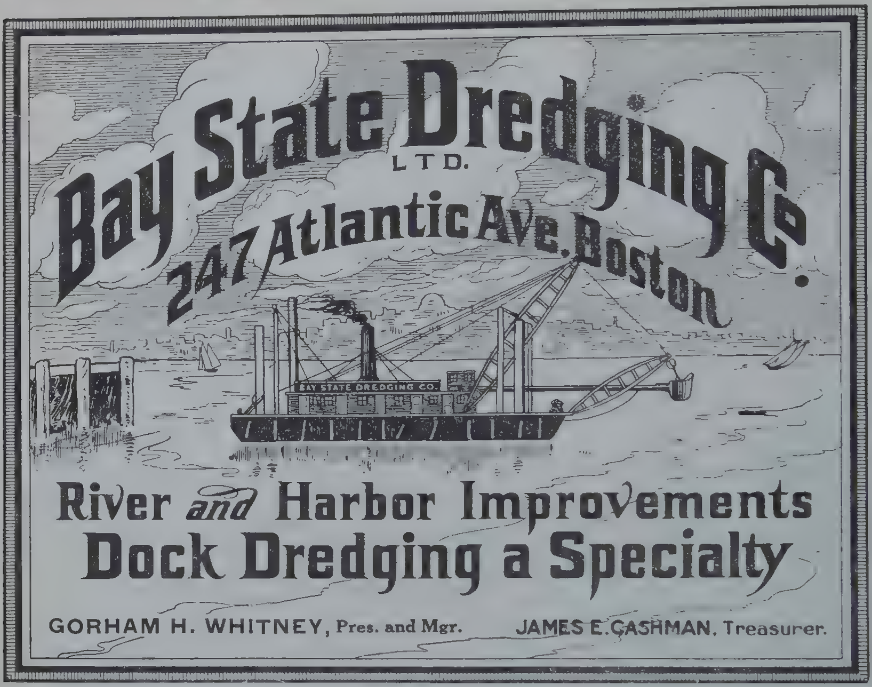
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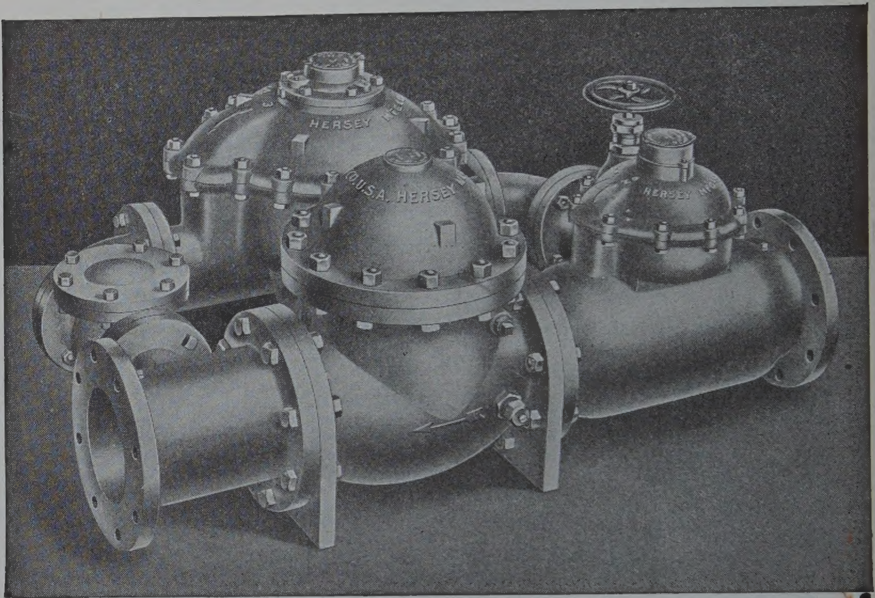

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